DEVELOPMENT OF CUTTING FLUID FROM THEVETIA PRUVENSSIA SEED OIL (*YELLOW OLEANDER)*

BY

BELLO JOHN KAREEM B.ENG (MECHANICAL)

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SUPERVISOR:

Prof. A.T ABDULLAHI

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DECLARATION

I hereby declare that this work is the product of my own research efforts, undertaken under the supervision of Prof. A.T Abdullahi and has not been presented elsewhere for the award of a degree or certificate. All sources have been duly acknowledged.

Signature ………………………

BELLO JOHN KAREEM

SPS/10/MPE/00001

Date…......................................

CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent preparation of the dissertation by **BELLO JOHN KAREEM, SPS/10/MPE/00001** were carried out under my supervision.

Prof. A.T ABDULLAHI ________________________ ______________

Supervisor Sign Date

ENGR. ABUBAKAR BABA ALIYU ______________ ______________

Head of Department Sign Date

APPROVAL PAGE

This is to certify that this dissertation has been read and approved by undersigned as meeting the requirements of the department of Mechanical Engineering, Faculty of Engineering, Bayero University, Kano in partial fulfillment for the award of the degree of

MASTER OF ENGINEERING (PRODUCTION).

…………………………… ………………………

Prof. A.T ABDULLAHI Date

Dissertation Supervisor

……………………………

Prof. A.U Alhaji ……………………..

Internal Examiner Date

…………………………… ………………………

External Examiner Date

DEDICATION

This dissertation is dedicated to my Creator who in His infinite mercy saved me from a deadly accident to come back to School and add more knowledge to serve humanity.

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First of all, I acknowledge the favour of Allah on me for inspiring me and guiding me throughout this research work and for granting me good health. The inspiration given to me by my father, Mallam Bello and mother Salamat who could neither write nor read but have educational foresight for their son is in no way measurable in the real sense.

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ABSTRACT

Thevetia peruvenssia seed oil was extracted, characterized and its potential use as cutting fluid was examined. A cutting fluid was developed from thevetia pruvenssia seeds (TPSF) oil. The physiochemical and mechanical performance of the fluid were measured. The performance of the developed cutting fluid was evaluated by a direct comparison with purchased conventional cutting fluid (castor oil), using the ability of each sample to effectively perform as coolant during machining operation. In the evaluation process, straight turning operation on lathe machine at various speeds, but equal time intervals of 5 minutes was used with a 0.5mm/min feed rate. It was found that both samples have similar cooling properties except at 140rpm to 180rpm when the standard coolant was better. The viscosity of TPSF measured at 40ºC is 29.50cSt which is lower than the soluble oil by 16%. The viscosity of TPSF measured at 100ºC is 10.85cSt which is higher than the soluble by 54%. The pH of the TPSF fluid was found to be 7.71compared to that of soluble oil of 10.3 which is an advantage because it is less corrosive.

The result of corrosion test shows that the corrosion level of TPSF is vestiges. The presence of unsaturated acid (oleic acid, 50.49%) which constitute the major component of the acid in the oil enhance the lubricity of the oil. The presence of free fatty acid (5.64%) in the oil determines its stability. This shows that the oil can be stored for a long period of time without spoil The flashpoint of TPSF (98ºC) shows that it is less hazardous to the operator and the environment. The pour point of TPSF (-1ºC) is high. This limits its use only in tropical countries like Nigeria. The presence of chlorine in the oil (0.16) acts as an antiseptic agent and it increases the emulsion life of the base oil. However, it was recommended that viscosity index improver is needed to enhance its viscosity level.

CHAPTER ONE

INTRODUCTION

Cutting fluids increase tool life and improve the efficiency of the production systems providing both cooling and lubricating the work surface.

Cutting fluids are used to reduce the negative effects of the heat and friction on both tool and work piece. However, the advantages caused by the cutting fluids have been questioned lately, due to several negative effects they have caused to the environment and health of workers.

When inappropriately discharged, cutting fluids may damage soil and water resources, causing serious environmental impacts. On the shop floor, the machine operators may be affected by the negative effects of cutting fluids, such as skin and respiratory problems for most machining processes, the use of cutting fluids is inevitable. For these cases it is necessary to develop alternative cutting fluid in order to avoid environmental problems. The most common types of lubricants are petroleum based. As the idea that oil may someday be depleted, industries have been searching for the cheap renewable sources of lubricant. Bio based lubricant have been the most promising as they have useful physical properties (Trans world, 2009).

Bio base lubricants are currently used in a limited number of environmentally- sensitive industrial applications such as agricultural machinery or machines in close proximity to water. They are also sometimes used in consumer goods such as petro/bio lubricant motor oil blends, but the high concentration of petroleum makes them harmful to the environment.

There are many lubricant alternatives available, they include synthetic or animal fat lubricants, but lubricants derived from vegetable have received most attention due to number of their useful physical properties. Bio-based lubricants have high lubricity, flash points and suitable viscosity indices. This work proposes a development of a plant based cutting fluid that can be used in machining process to replace the commonly used soluble oil cutting fluid.

1.1 Statement of the Problem

The chemically based cutting fluids used nowadays have some adverse effects on the machine operator and the environment compared to the environmentally friendly plant based cutting fluids. Thus, plant based cutting fluid when developed would help to eliminate some of these adverse effects and convert plant waste to a useful product that will ease machining processes. Also, there has been inadequate cutting fluid in the market for machine operator to make rational choice on the type of cutting fluid to purchase. Therefore, the need arise for search for TPSF.

1.2 Significance of the Research

1. The search for plant waste source of oil based material to develop a cutting fluid that will be cheaply available for use and to replace the mineral oil in the future.
2. To make rational choice of cutting fluid competitive in the market.

1.3 Aim and Objectives of the Research:

1.3.1 Aim of the Research

The aim of this work is to develop a cutting fluid from a local source of oil, thevetia plant seeds oil that will be environmental friendly, improve the performance of machining operation and make the choice of cutting fluid competitive in the market.

1.3.2 Objectives of the Research

1. To extract oil from TPSO and characterize it for potential use as cutting fluid.

2. To carry out performance evaluation using the developed cutting fluid in turning operation.

3. To determine whether the developed vegetable based oil fluid is suitable for machining operation.

4. To determine whether the developed cutting fluid will inhibit rust on the machine parts.

5. To develop a cutting fluid that is non-toxic to the environment and the operator.

6. The search for bio-based coolant that has attractive attention to conventional coolants

1.4 Methodology

1. Collection of necessary information from literature review
2. Collection of thevetia seeds and extraction of thevetia oil
3. Measurement of density, specific gravity, Viscosity, pH, Corrosion test, Pourpoint, Flashpoint, Viscosity index, Chlorine, Free fatty acid, Fatty acid composition, Active sulphur and Total sulphur.
4. Cutting fluid formulation
5. Measurement of heat generated on turning operation
6. Data analysis and conclusion

1.5 Scope and Limitation of the Work

The work is limited to; Extraction and characterization of thevetia seeds oil and assessment of its potential use as cutting fluid by testing its ability to conduct heat away from the cutting zone during machining operation.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

One of the interesting recent developments is a growing realization that bio resources present practical alternatives to fuels and lubricants derived from liquid fossil fuels. About 30 years ago in Tanzania, locally pressed castor oil, strained through an old sock was used as gearbox engine oil (Weiss, 1983). That this was no eccentricity was shown by the many tests carried out on its uses as lubricating oil and its eventual acceptance as a jet engine lubricant (Weiss, 1983).

However, no pure vegetable or mineral oil possesses all the properties required by modern technology in machining processes, therefore, a mixture of some sort is necessary. This has led to the development of several cutting fluids using many soluble mineral oils (Akpobi et al, 2002).

Annually,forty (40) million tonnes of lubricants are consumed worldwide, and are used in everything ranging from car engines to office chairs. Conventional lubricants are more commonly used than bio based lubricants because they are cheap. Bio based lubricant are attractive alternatives because of their useful physical properties, and they are clean and renewable (Theolen and Orlogee, 2002). They are clean and renewable and easily disposed of as they are no-toxic and biodegradable. These properties make bio-based lubricants attractive alternative to petrol based lubricant (Honary, 2001).

Cutting lubricants may consist of pure oil, a mixture of two or more oils or a mixture of oil and water (Akpobi et al, 2002). Oils are generally divided into two groups: the fixed oils and the mineral oils. The fixed oils have greater "oiliness" than the mineral oils, but they are not so stable and tend to become gummy and decompose when heated. In this group are animal and vegetable oils. On the other hand, the mineral oils group is obtained from crude petroleum mined from the oil fields. The most common type of lubricant used for cutting is soluble oil, which when mixed with water, forms a white solution known as "suds" or "slurry". This has better cooling properties than oil, but does not lubricate as much. The oil part of it is generally a mineral oil mixed with a soap solution (Chapman, 1975).

Cutting fluids produce three positive effects in the process: heat removal elimination, lubrication on the chip–tool interface and chip removal (Lopez de Lacalle et al., 2006).

During machining operations, heat is generated and this has adverse effects on work piece surface finish and dimensional accuracy, tool wear and life, as well as production rate.

Lubricants are therefore employed in machining operations to either achieve cooling, cooling and lubrication, lubricate mainly, or minimize chip adhesion to work piece or tool; and the goal of employing a lubricant in any machining operation is dependent on choice from among the listed functions (Chernor,1972) (Chapman,1975).

Whichever function a cutting fluid is to serve in any machining operation, it must possess some qualities, which have been identified (Sharma, 2005) as: high decomposition or oxidation temperature, must not be gummy, should not foam or smoke unduly, must not be a contaminant to lubricants used elsewhere in the machine. If these qualities are lacking, the cutting fluid may result in serious ecological or health issues (Kalhofe, 1997). It has been observed (Ibhadode, 2001) that expenses on cutting fluids form major parts of manufacturing costs per part produced.

It is therefore, a cost cutting measure to develop cost effective and efficient cutting fluids for machining processes. This could be achieved through the use of cheap and readily available vegetable oils.

In order to make machining process more ecologically safe, the minimal quantity lubrication has been accepted as a successful near-dry applications because of its environmentally friendly characteristics (Sokovic et al., 2001) (Dhar et al.,2006)(Suda et al.,2004).

This work therefore will take its objective the development and performance evaluation of cutting fluid from vegetable oil (yellow oleander) and available additives. This will be achieve by formulation and testing the ability of the developed cutting fluid to conduct heat away from the cutting zone as well as the determination of surface finish, chip thickness. In order to establish their suitability as cutting fluids, the developed oil values were compared with those of an established conventional soluble cutting fluid.

Fig 1.0: YELLOW OLEADER

Yellow oleander is a tropical evergreen shrub or small tree that is in the same family as and closely related to Nerium oleander*,* commonly known as oleander. Yellow oleander will grow to 20-30’ tall in its native habitat. It is an upright shrub that features willow-like, linear-lanceolate, glossy green leaves (to 6-7” long) with distinctive midribs and large 3” long funnel-shaped sometimes-fragrant yellow (less commonly apricot) flowers in few-flowered terminal clusters (cymes). Flowers bloom from summer to fall. Flowers give way to black seed pods, each containing 1-2 nut-like seeds.

2.1 Method of extracting seed oil

There are three methods that can be used for the extraction of seeds oil;

Hydraulic press; screw press and solvent extraction (Singh et al, 1987). The hydraulic press involves squeezing the oil seeds in a frame. The machine is simple but inefficient and it is no longer in use. Like hydraulic presses, screw press is simple but they are relatively efficient and are suited to the conditions found in Africa.

In this research, chemical extraction will be used.

In recent times, the world has been confronted with an energy crisis due to depletion of resources and increased environmental problems. This situation has led to the search for an alternative fuel, which should be not only sustainable, but also environmental friendly

(Barnwal and Sharma,2005). Various methods for recovering (extracting) this oil from the seeds have been investigated. Conventional method such as solvent extraction is the most widely

used technique, owing to its high efficiency in oil recovery (90 to 98%). But the major disadvantage in using solvent extraction technique is its high energy input and toxicity of the solvent. This has lead to the development of enzyme-based techniques (Sharma et al., 2007). The presence of certain enzymes during extraction enhances oil recovery by breaking cell walls and oil bodies. As plant cell walls have a complex structure, different enzymatic preparation is required to break up the cell wall. This process is eco-friendly and does not produce volatile organic compounds as atmospheric pollutants. The major disadvantage associated with this is the long process time necessary for the enzymes to liberate oil bodies. Another factor is the use of enzymes which are not commercially available (Gupta et al., 2005). This prevents the use of this method in regular day to day life. Thus, the present study deals with extraction of oil by use of solvent extraction and enzymatic extraction techniques. The parameters taken into consideration were the type of organic solvent and type of separation/extraction technique

2.2 MATERIALS AND METHODS OF EXTRACTING SEEDS OIL

2.2.1 Solvent extraction techniques

Seeds are crack and the shells carefully removed. The seeds thus obtained are used for oil extraction. The seeds are grounded by using mechanical method (mortar and pestle).The oil can be extracted by using different organic solvents (20 ml) such as petroleum ether, hexane and isopropanol. The extracted lipid can be obtained by different techniques such as filtration, centrifugation and separating funnel; in order to get rid of the solid from solvent before the solvents was removed. Extracted seed oil is stored in freezer at -20°C for subsequent physicochemical analysis (Sharma et al., 2007).

2.2.2 Aqueous enzymatic oil extraction (AEOE) from seed kernels

Seeds were soaked in water for 2 hours. The soaked seeds is ground (without addition of water to the soaked seeds) to a thick paste by using mortar and pestle. This paste was then dispersed in distilled water at 1:2 (w/v) pastes to water ratio followed by gentle stirring with a magnetic stirrer. Cellulase (250 mg) (Himedia 15FTU/ml) will be added before the pH of the slurry was adjusted to 4 by adding appropriate amount of 0.5 N HCl or NaOH.The enzyme mixture will be then incubated overnight at 40°C with constant shaking at 100 rpm. The upper oil phase was collected by centrifugation at 10,000 x g for 20 min. A control (aqueous oil extraction, AOE) will also be carrying out for the earlier mentioned extraction during which no enzyme was added (Sharma et al.2002).

2.2.3 Soxhlet extraction

The seed kernels are grounded using a mechanical method and defatted in a soxhlet apparatus. The extraction was carried out by using three different solvents such as hexane, isopropanol and petroleum ether. The process continued for 6 hours. Solvent is then removed by vacuum evaporation and exposure to heat in a drying oven at 50°C. The amount of oil recovered can be calculated as percentage of total oil present in *the* seeds kernels.(Akbar et al,2009)

2.3 CHARACTERIZATION OF COOLANT OIL

The parameters that influence the efficiency of cutting fluid are listed below:

2.4.1 Acid value, %FFA

The acid value of the oil is determined by dissolving 5 g oil sample in 25 ml fat solvent (95% ethanol: ether; 1:1). The earlier mentioned solution was titrated with 0.1 N KOH using Sphenolphthalein as an indicator. The titration is carried out until faint pink colour appears. Acid value is calculated as per the standard formula given by Sadashivam et al. biochemical methods, II edition as FFA = $\frac{Titre*molarity\ of\ base*28.2}{weight\ of\ sample}$

2.4.2 Measurement of Density

Density of a substance is the ratio of the mass of the substance to its volume

The mass of known volume of oil sample is measured and the density of oil is calculated from:

density = $\frac{mass}{volume}$ ---(1)

2.4.3 Specific gravity of TP Oil

The specific gravity of a substance is the ration of the density of the substance to the density of water. The specific gravity of the oil can be calculated as:

$$\text{specific gravity} = \frac{density\ of\ the\ oil}{density\ of\ water} \text{---} (2)$$

2.4.4 Flash point of TP Oil

The flash point is often used as a descriptive characteristic of liquid fuel, and it is also used to help characterize the fire hazards of liquids. "Flash point" refers to both flammable liquids and combustible liquids. There are various standards for defining each term. Liquids with a flash point less than 60.5 or 37.8 °C (141 or 100 °F)depending upon the standard being applied are considered flammable, while liquids with a flash point above those temperatures are considered combustible (Stachowiak and Andrew, 2001)

2.4.5 Pensey Marten closed flash point apparatus

The flash point of oil using the experimental procedure and Stanhope-seta as specified by IP 34/88 and D93-94.The process is continually repeated until the test flame applied until it causes a distinct flash in the interior of the cup. The flash point is read from the thermometer and recorded.

Table 2.1 FlashPoint (NEPA 30; 2012)

Hazard	Flash Point
Very Low Hazard	Flash point > 200°F (93°C)
Moderate Low Hazard	Flash point 150°F to 200°F (66°C to 93°C)
High to Moderate Hazard	Flash point 100°F to 150°F (38°C to 66°C)
Extreme to High Hazard	Flash point 0°F to 100°F (-18°C to 38°C)
Extreme Hazard	Flash point < 0°F (-18°C)

2.4.6 pH

Acidic and basic are two extremes that describe chemicals, just like hot and cold are two extremes that describe temperature. Mixing acids and bases can cancel out their extreme effects; much like mixing hot and cold water can even out the water temperature. A substance that is neither acidic nor basic is neutral.

The pH scale measures how acidic or basic a substance is. It ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic, and a pH greater than 7 is basic. The cutting fluid pH can be determined using a digital PH meter.

2.4.7 Viscosity

Viscosity is the measure of the internal friction of a fluid. This friction becomes apparent when a layer of fluid is made to move in relation to another layer. The greater the friction, the greater the amount of force required to cause this movement, which is called shear. Shearing occurs whenever the fluid is physically moved or distributed, as in pouring, spreading, spraying, mixing, etc. Highly viscous fluids, therefore, require more force to move than less viscous materials.

The fundamental unit of viscosity measurement is the poise. Ball viscometer is used for measuring viscosity of oil (Ávila, 2001)

2.4.8 Viscosity Index

Viscosity index (VI) is an arbitrary measure for the change of viscosity with temperature. It is used to characterize lubricating oil in the automotive industry.

The viscosity of liquids decreases as temperature increases. The viscosity of a lubricant is closely related to its ability to reduce friction. Generally, the least viscous lubricant which still forces the two moving surfaces apart is desired. If the lubricant is too viscous, it will require a large amount of energy to move (as in honey); if it is too thin, the surfaces will come in contact and friction will increase.

As stated above, the Viscosity Index highlights how a lubricant's viscosity changes with variations in temperature (Stachowiak and Andrew,2001)

Table2.2 Viscosity Index (Stachowiak and Andrew)

Viscosity Index	Classification
Below 35	Low
35..80	Medium
80..110	High
110 above	Very High

Viscosity index improving additives and higher quality base oils are widely used nowadays which increase the Viscosity index attainable beyond the value of 100. The Viscosity Index of synthetic oils ranges from 80 to over 400.

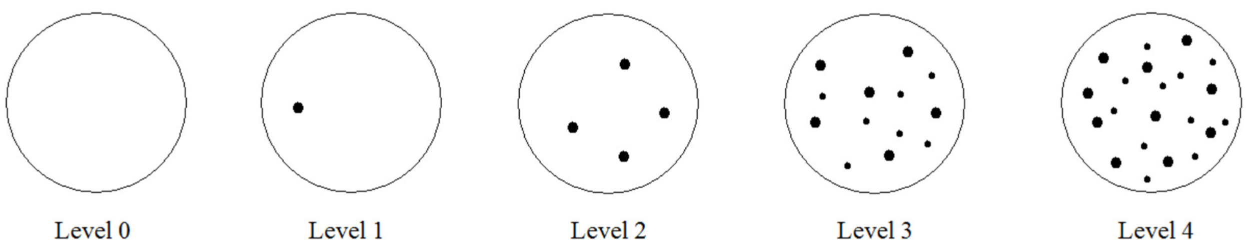
The viscosity index can be calculated using the following formula:

$$V = 100\frac{(L-U)}{(L-H)} \qquad (3)$$

where V indicates the viscosity index, U the kinematic viscosity at 40 °C (104 °F), and L & H are various values based on the kinematic viscosity at 100 °C (212 °F) available in ASTM D2270 (Stachowiak and Andrew, 2001)

2.4.9 Corrosion Test (ASTM D4627)

This test involves in measuring the corrosion grade of cutting fluid by its contact with mild steel. Some grams of mild steel chips will be washed in acetone and dried, placed on a piece of filter paper in a Petri dish. The chips will be evenly spaced around the filter paper, prevented from contacting one another and humidified in 2ml of the test cutting fluid. The chips will then be left in the covered Petri dish for 2 hours. At the end of 2 hours, the mild steel chips will be discarded and the filter papers would be rinsed in acetone. The corrosion grade of the cutting fluid would be measured by observing how many spots appear on the filter paper surface. (M., Mijanovic, K., 2001)



The table below shows the corrosion grade table.

Table 2.3 Corrosion Grades (Mijanovic, 2001)

Corrosion Grade	Mean	Filter paper surface
0	Without corrosion	Unaltered or “stainless”
1	Little corrosion	Up to three corrosion spots, with average diameter lower than 1 mm
2	Slight corrosion	Stains covering less than 1% of the filter paper surface, but presenting a higher number of stains than those established for Level 1 or with average size higher than 1 mm
3	Moderate corrosion	Stains covering between 1% and 5% of the surface of the filter paper used
4	Severe corrosion	More than 5% of the paper surface affected

2.4.10 Pour Point

A cylindrical test tube was filled with TPSF oil to a known level and clamped with a wooden clamp bearing thermometer. The sample was allowed to cool below 0^{o}C in ice/salt bath. It was then removed and tilted on the clamp. The setup was observed at regular interval. The lowest temperature at which the oil begins to flow was recorded. This gives the pour point of the oil.

2.4.11 Chlorine Weight

Chlorine weight can be measured with UV spectrometer.

Chlorine in the sample as hypochlorus acid or hypochlorite ion immediately reacts with DPD (N,N-diethyl-phenylene diamine) indicator to form a pink colour, the intensity of which is proportional to the chlorine concentration. The test results are measured at 530nm.

2.4.12 Active sulphur and sulphur weight

Sulphur in oil is not desirable because of the corrosiveness of sulphur compounds in the oil.

Materials and reagents: Standard $BaCl_2$ solution (1ml=0.0004gram of sulphur), 0.02MKOH, 0.02MHCl, phenolphthalein indicator, Tetrahydroxyquinone (dipper) indicator, ethyl alcohol.

Procedure: 0.8g of oil sample was weighed and sparked with oxygen. The sample obtained was treated with bromine water. The resulting solution was subjected to evaporation to remove excess water present and the then cooled.25ml of the solution was pipette to the flask. A few drop of phenolphthaline was added followed by KOH. A red colour solution was formed and this was discharged by adding HCl. 25ml of alcohol and a dipper of indicator was added. The resulting solution was titrated with $BaCl_2$ solution until the solution changes sharply from yellow to red that is permanent with strong shaking.

(Robert .T sheen and H. Lewis)

Amount of sulphur present is given as

$$\frac{\text{ML of BaCl2 x stenght of BaCl2(in grams of sulphur per ml)}}{\text{weight of oil sample in gram}} \text{ x100 x 4 -------------------(4)}$$

2.5 Cutting Fluid Formulation

ASTM D 974 standard is use to formulate the fluid.

The following steps are methods are used in formulating cutting tools:-

Mixing: 500ml of fixed oil was measured (using 1-litre measuring cylinder) and mix with water in oil to water ratio of 1:10 for 2 min. After all substances were added, they were mixed together for 15 min.

The cutting fluid developed has the following formula:

Table 2.4 Cutting fluid formula

Material	Function	Content (% volume/volume)
Plant oil (thevetia seeds)	Base oil	80
Washing soap	Emulsifier	10
Phenol	Disinfectant	5
Sulphur	Extreme pressure agent	5

((Akpobi et al, 2002)

2.6 CUTTING FLUID

Cutting fluid is a type of coolant and lubricant designed specifically for metalworking and machining processes.

There are various kinds of cutting fluids, which include oil, oil-water emulsions, pastes, gels, aerosols (mists), and air or other gases. They may be made from petroleum distillates, animal fats, plant oils, water and air, or other raw ingredients. Depending on context and on which type of cutting fluid is being considered, it may be referred to as cutting fluid, cutting oil, cutting compound, coolant, or lubricant. Cutting fluids are used in metal machining for a variety of reasons such as improving tool life, reducing work piece thermal deformation, improving surface finish and flushing away chips from the cutting zone (Akpobi et al, 2002)

2.6 The properties that are sought after in a good cutting fluid are the ability to:

- Keep the work piece at a stable temperature (critical when working to close tolerances). Very warm is OK, but extremely hot or alternating hot-and-cold are avoided.
- Maximize the life of the cutting tip by lubricating the working edge and reducing tip welding.
- Ensure safety for the people handling it (toxicity, bacteria, and fungi) and for the environment upon disposal.
- Prevent rust on machine parts and cutters (Suda, Wakabayashi, Inasaki, 2004)

2.7 FUNCTION OF CUTTING FLUID

2.7.1 Cooling:

Metal cutting operations generate heat due to tool friction and energy lost deforming the material. The surrounding air is a poor coolant for the cutting tool because it conducts heat poorly and has low thermal mass. Ambient-air cooling is adequate for light cuts and low duty cycles typical of maintenance, repair and operations (MRO) or hobbyist work. However, production work requires heavy cutting over long time periods and typically produces more heat than air cooling can remove. Rather than pausing production while the tool cools, using liquid coolant removes significantly more heat more rapidly, and can also speed cutting and reduce friction and tool wear (De Chiffre 2002)

2.7.2 Lubrication:

Besides cooling, cutting fluids also aid the cutting process by lubricating the interface between the tool's cutting edge and the chip. By preventing friction at this interface, some of the heat generation is prevented. This lubrication also helps prevent the chip from being welded onto the tool, which interferes with subsequent cutting (De Chiffre, 2002)

2.8 TYPES OF CUTTING FLUID

Practically all cutting fluids presently in use fall into one of four categories:

- Straight oils
- Soluble oils
- Semi synthetic fluids
- Synthetic fluids (De Chiffre, 2002)

2.8.1 Straight oils are non-emulsifiable and are used in machining operations in an undiluted form. They are composed of a base mineral or petroleum oil and often contain polar lubricants such as fats, vegetable oils and esters as well as extreme pressure additives such as Chlorine, Sulphur and Phosphorus. Straight oils provide the best lubrication and the poorest cooling characteristics among cutting fluids.

2.8.2 Synthetic Fluids contain no petroleum or mineral oil base and instead are formulated from alkaline inorganic and organic compounds along with additives for corrosion inhibition. They are generally used in a diluted form (concentration ration = 3 to 10%). Synthetic fluids often provide the best Collin performance among the cutting fluid.

.**2.8.3 Soluble Oil Fluids** form an emulsion when mixed with water. The concentrate consists of a base mineral oil and emulsifiers to help produce a stable emulsion. They are used in a diluted form (usual concentration = 3 to 10%) and provide good lubrication and heat transfer performance. They are widely used in industry and are the least expensive among all cutting fluids.

2.8.4 Semi-synthetic fluids arise essentially combination of synthetic and soluble oil fluids and have characteristics common to both types. The cost and heat transfer performance of semi-synthetic fluids lie between those of synthetic and soluble oil fluid.

2.9.0 Cutting fluid can be also classified in following categories;

2.9.1 Liquids

There are generally three types of liquids: mineral, semi-synthetic, and synthetic. Water is a great conductor of heat but has drawbacks as a cutting fluid. It boils easily, promotes rusting of machine

Therefore, other ingredients are necessary to create an optimal cutting fluid. Mineral oils, which are petroleum based, first saw use in cutting applications in the late 19th century. These vary from the thick, dark, sulfur-rich cutting oils used in heavy industry to light, clear oils.

2.9.2 Pastes or gels

Cutting fluid may also take the form of a paste or gel when used for some applications, in particular hand operations such as drilling and tapping. In sawing metal with a band saw, it is common to periodically run a stick of paste against the blade. This product is similar in form factor to lipstick or beeswax. It comes in a cardboard tube, which gets slowly consumed with each application.

2.9.3 Aerosols (mists)

Some cutting fluids are used in aerosol (mist) form (air with tiny droplets of liquid scattered throughout). The main problems with mists have been that they are rather bad for the workers, who have to breathe the surrounding mist tainted air, and that they often don't even work very well. Both of those problems come from the imprecise delivery that often puts the mist everywhere and all the time except at the cutting interface, during the cut—the one place and time where it's wanted. However, a newer form of aerosol delivery, MQL (minimum quantity of lubricant), avoids both of those problems.

2.9.4 Air or other gases (e.g., nitrogen)

Ambient air, of course, was the original machining coolant. Compressed air, supplied through pipes and hoses from an air compressor and discharged from a nozzle aimed at the tool, is sometimes a useful coolant. The force of the decompressing air stream blows chips away, and the decompression itself has a slight degree of cooling action ($pV= nRT$); lowering the pressure lowers the temperature).

2.10 Importance of Cutting Fluid

2.10.1 The primary needs of cutting fluids are (In Machining):

- Lubricating the cutting process primarily at low cutting speeds
- Cooling the work piece primarily at high cutting speeds
- Flushing chips away from the cutting zone

2.10.2 Secondary importance includes:

- Corrosion protection of the machined surface
- enabling part handling by cooling the hot surface

2.10.3 Process effects of using cutting fluids in machining include:

- Longer Tool Life.
- Reduced Thermal Deformation of Work piece.
- Better Surface Finish (in some applications).
- Ease of Chip and Swarf handling (Chapman, 1975)

2.11 ADDITIVES FOR LUBRICANTS

Additives are substances formulated for improvement of the anti-friction, chemical and physical properties of base oils (mineral, synthetic, vegetable or animal), which results in enhancing the lubricant performance and extending the equipment life. Combination of different additives and their quantities are determined by the lubricant type (Engine oils, Gear oils, Hydraulic oils, cutting fluids, Way lubricants, compressor oils etc.) and the specific operating conditions (temperature, loads, machine parts materials, environment).Amount of additives may reach 30%.

- Friction modifiers
- Anti-wear additives
- Extreme pressure (EP) additives
- Rust and corrosion inhibitors
- Anti-oxidants
- Detergents
- Dispersants
- Pour point depressants
- Viscosity index improvers
- Anti-foaming agents (Wood 2005)

2.11.1 Friction Modifiers

Friction modifiers reduce coefficient of friction, resulting in less fuel consumption. Crystal structure of most of friction modifiers consists of molecular platelets (layers), which may easily slide over each other.

The following Solid lubricants are used as friction modifiers:

- Graphite;
- Molybdenum disulfide;
- Boron nitride (BN);
- Tungsten disulfide (WS_2);
- Polytetrafluoroethylene (PTFE). (Wood 2005)

2.11.2 Anti-Wear Additives

Anti-wear additives prevent direct metal-to-metal contact between the machine parts when the oil film is broken down. Use of anti-wear additives results in longer machine life due to higher wear and score resistance of the components. The mechanism of anti-wear additives: the additive reacts with the metal on the part surface and forms a film, which may slide over the friction surface.

The following materials are used as anti-wear additives:

- Zinc dithiophosphate (ZDP);
- Zinc dialkyldithiophosphate (ZDDP);
- Tricresylphosphate (TCP). (Wood 2005)

2.11.3 Extreme Pressure (EP) Additives

Extreme pressure (EP) additives prevent seizure conditions caused by direct metal-to-metal contact between the parts under high loads. The mechanism of EP additives is similar to that of anti-wear additive: the additive substance form a coating on the part surface. This coating protects the part surface from a direct contact with other part, decreasing wear and scoring. The following materials are used as extra pressure (EP) additives:

- Chlorinated paraffins;
- Sulphurized fats;
- Esters;
- Zinc dialkyldithiophosphate (ZDDP);
- Molybdenum disulfide; (Wood 2005)

2.11.4 Rust and Corrosion Inhibitors

Rust and Corrosion inhibitors, which form a barrier film on the substrate surface reducing the corrosion rate. The inhibitors also absorb on the metal surface forming a film protecting the part from the attack of oxygen, water and other chemically active substances.

The following materials are used as rust and corrosion inhibitors:

- Alkaline compounds;
- Organic acids;
- Esters;
- Amino-acid derivatives. (Wood 2005)

2.11.5 Anti-Oxidants

Mineral oils react with oxygen of air forming organic acids. The oxidation reaction products cause increase of the oil viscosity, formation of sludge and varnish, corrosion of metallic parts and foaming. Anti-oxidants inhibit the oxidation process of oils. Most of lubricants contain anti-oxidants.

The following materials are used as anti-oxidants:

- Zinc dithiophosphate (ZDP);
- Alkyl sulfides;
- Aromatic sulfides;
- Aromatic amines;
- Hindered phenols. (Wood 2005)

2.11.6 Detergents

Detergents neutralize strong acids present in the lubricant (for example sulfuric and nitric acid produced in internal combustion engines as a result of combustion process) and remove the neutralization products from the metal surface. Detergents also form a film on the part surface preventing high temperature deposition of sludge and varnish. Detergents are commonly added to Engine oils.

Phenolates, sulphonates and phosphonates of alkaline and alkaline-earth elements, such as calcium (Ca), magnesium (Mg), sodium (Na) or Ba (barium), are used as detergents in lubricants. (Wood 2005)

2.11.7 Dispersants

Dispersants keep the foreign particles present in a lubricant in a dispersed form (finely divided and uniformly dispersed throughout the oil). The foreign particles are sludge and varnish, dirt, products of oxidation, water etc.

Long chain hydrocarbons succinimides, such as polyisobutylene succinimides are used as dispersants in lubricants.

2.11.8 Pour Point Depressants

Pour point is the lowest temperature, at which the oil may flow. Wax crystals formed in mineral oils at low temperatures reduce their fluidity. Pour point depressant inhibits formation and agglomeration of wax particles keeping the lubricant fluid at low temperatures. Co-polymers of polyalkyl methacrylates are used as pour point depressant in lubricants. (Wood 2005)

2.11.9 Viscosity Index Improvers

Viscosity of oils sharply decreases at high temperatures. Low viscosity causes decrease of the oil lubrication ability. Viscosity index improvers keep the viscosity at acceptable levels, which provide stable oil film even at increased temperatures. Viscosity improvers are widely used in multigrade oils, viscosity of which is specified at both high and low temperature. Acrylate polymers are used as viscosity index improvers in lubricants.

2.11.10 Anti-Foaming Agents

Agitation and aeration of a lubricating oil occurring at certain applications (Engine oils, Gear oils, Compressor oils) may result in formation of air bubbles in the oil - foaming. Foaming not only enhances oil oxidation but also decreases lubrication effect causing oil starvation. Dimethylsilicones (dimethylsiloxanes) is commonly used as anti-foaming agent in lubricant. (Wood 2005)

2.12: SELECTION OF CUTTING FLUIDS

The selection of cutting fluids for a particular machining operation depends on two main factors, type of machining work to be done, and the material being machined (Dhar,, Islam, 2006). It is thus possible to draw up lists of recommendations in two different forms. One form based on the operation. The other based on the type of material being worked. The operational table below provides a more valuable suggestion of cutting fluids for particular operations.

Table 2.5 type of machining operation and its cutting fluid(Chernor N, 1972)

s/n	Types of operation	Cutting fluid used
1	Automatic machines	Compounded oil or mineral oil or organic oil.
2	Boring	Emulsion(water+ mineral oil +soap)
3	Broaching	Compounded oil or mineral oil or emulsion
4	Drilling	Emulsion(water+ mineral oil + soft soap)
5	Milling	Emulsion(water+ mineral oil + soft soap)
6	Parting off	Compounded oil or emulsion
7	Planning	Dry
8	Tapping	Mineral oil or Organic oil or Emulsion.
9	Threading	Compounded or organic oil or white lead + oil+ sulphur
10	Turning	Emulsion(water+ mineral oil + soft soap)
11	Turret lathe work	Compounded oil or emulsion

2.13. MACHINING PROCESSES

There are various techniques of metal cutting process which includes: Drilling, Turning, Milling, shaping, planning, broaching, grinding and ultrasonic machining (USM)

But in this research, turning operation will be used because of the cutting fluid type.

2.14: FORCE EFFECTS

Measurements during modern processing techniques are carried out from different points of view and hence different techniques are used. Generally the interest is either in process control or for process improvement. On this basis, the study of work- tool interaction forces is of great importance and practical interest in the entire chip forming operation (Xavior, Adithan,2009)

2.15: FORCES INVOLVED IN MACHINING PROCESSESS

During the machining process the resultant force acts on the tool and it distributes itself along the chip-tool interface and is then distributed through the chip to the shear line, where yielding occurs. The actual force distribution along this surface may be resolved into normal and tangential components which are related by the coefficient of friction (Chapman 1976). The stress component along the shear line is K, while that perpendicular to this line is R. These are the only surface on which forces are acting, and for equilibrium of the chip, the forces must be equal to each other.

2.16: THE IMPORTANCE AND EFFECTS OF CUTTING FLUID ON CUTTING PARAMETERS DURING MACHINING OPERATION AND ITS MEASUREMENT

Owing to high pressure and low speeds in most metal forming operations lubrication is of the boundary lubricants, such as fatty oils, fatty acids, soaps and wax are used (ASTM, 1967).the molecules of polar substance in boundary lubricants have long carbon chains with one or more chemically active groups at one end called polar groups. The polar groups adhere strongly to the work metal and tool causing the long carbon chains to be oriented approximately at right angles to the metal surfaces. These oriented films of polar substances (sometimes called oiliness agents, and are usually several molecules thick), minimize friction and metal to metal contact.

Shaw(1982) and Bowden and Tabor(1950), had observed that the longer the chain lengths of the fatty acids contents the more the area the fluid will protect from the rubbing effect of the sliding chip- tool interface, hence an improved tool life. Oleic and linoleic acids are also unsaturated fatty acids and so they are reactive (due to the presence of double bonds.) in addition to the presence of carboxylic groups. They therefore, contribute to the formation of the absorbed layer by the local oils unto metal surface (Heisel, 1998)

Table 2.6: chemical composition of local oil (Onaga, 1988)

FATTY ACID	**CHAIN LENGH**	**% OF FATTY ACIDS IN VARIOUS OILS**					
		PALM KERNEL	**COTTON SEED OIL**	**SOYA BEANS OIL**	**PALM OIL**	**G/NUT OIL**	**SHEAR BUTTER OIL**
Myristic	14.0	17.0	1.0	0.1- 0.4	1.7	-	-
Palmitic	16.0	8.0	21.5	7-11	42.3	7.5	5.7
Stearic	18.0	2.0	2.0	2.4-6	52.0	4.5	41
Caprytic	8.0	3.0	-	-	-	-	-
Capric	10.0	4.0	-	-	-	-	-
Lauric	12.0	51.0	-	-	-	-	-
Arachidic	2.0	-	-	-	-	3.0	-
Beharic	22.0	-	-	0.3-2.4	-	2.0	-
Lignoceric	24.0	-	-	-	-	2.0	-
Oleic	18.0	13.0	24	22-34	40.6	62.0	49.0
Linoleic	18.0	2.0	46	50-60	9.9	20.0	4.3

Previous studies (Greenwood, 1929)(Mital, 977) (Ajala, 1981) have shown that local oils investigated are mainly fatty acids in composition (table2.3)With the presence of carboxylic group the saturated fatty acids in the oils help in maintaining a strong molecular adherences of the fatty oils to metal surfaces thereby minimizing friction.

Due to continued use, cutting tools fail to perform satisfactorily as a result of physical loss of the cutting edge (wear) which leads to loss of dimensional accuracy, excessive surface roughness and increased power requirements.

In the cutting of metals, work is done in the plastic deformation of the layer being cut at the primary shear plane, in overcoming friction on the tool- chip interface called the secondary shear plane and the layer adjoining machined surface and the tool flank or the tertiary shear plane (Smith, 1993). The heat generated passes into the tool and reduces its hardness and makes it less wear- resistance use of cutting fluid ameliorates these adverse effects with the best fluid producing the best result. When coolants are used chips are thinner; chips were collected and their thickness measured with a micrometer screw gauge (Lopez de Lacalle, Ângulo, 2006)

When lubricants are used, chips are thinner, meaning that a better lubricant should give a higher reduction of chip compression (Lopez de Lacalle, Ângulo, 2006) and reduction of chip thickness with speed and feed is an indication of reduction of cutting force, power consumed and temperature and that these depend on the cutting fluids used (Kalhofer,1997).

Fatty acids form salts (soaps) with metal ions because of the presence of terminal carboxyl groups. Their function may be one of affecting a dispersion of particulate matter and new trailing acids as well as acting as rust inhibitors.

Due to the presence of double bond in unsaturated fatty acids, the addition of halogens such as cl_2 and I_2 is done easily. Chlorine is an extreme pressure element which prevents seizure and welding between metal surface under conditions of extreme pressure and temperature. They are therefore good as extreme pressure base oils. Chlorine is also an antiseptic agent, which prevents odor and together with sodium increases the emulsion life of the base oil.

Cutting fluids promote the reduction in heat evolution (by facilitating chip formation and reducing friction), and also absorb and carry away part of the generated heat, thereby lowering the temperature (Arshinov and Alekseev, 1973)

2.17: REVIEW OF PAST WORK

Greenwood, 1929 carried out analysis of the local vegetable based oils (tallow, rape oil) and verified the percentage of fatty acids and confirmed the presence of palmitic, stearic, oleic and linoleic acids in reasonable quantities.

Obi et al, 2000 carried out the effects of vegetable- based oils on cutting parameters in turning operation. The force and apparent coefficient of friction effects of three vegetable-based oils, groundnut, cottonseed oil and palm oil were assessed from values obtained from cutting dynamics by considering the cutting parameters of rake angle, depth of cut and chip thickness in the orthogonal cutting of mild steel, at varying cutting speeds and feed rates. The result showed that the vegetable- based oils have better lubrication potentialities than the soluble usually employed in most machining operations based on their ability to reduce chip compression, apparent coefficient of friction and cutting force.

De Chiffre et al, 2001 investigated effect of vegetable based cutting oil on cutting forces and power. AISI 316L stainless steel work pieces were machined with drilling, core drilling, reaming and tapping using HSS-E tools. From the comparison of performance results obtained from two cutting fluids showed that the vegetable based cutting oils were better than the commercial mineral oil.

Adithan et al , 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.

Other works on lubricants' development from vegetable based oils are those of Oyinlola (1992) who tried the oils as cold rolling lubricants for steel and Nylor(1995) who checked the suitability of the oils as extrusion lubricants.

Agwandas (1995) used some of the oils to determine tool life in machining of Aladjia ST60-2 steel. Later Obi and Oyinlola (1996) confirmed the suitability of these oils as wire drawing lubricants for copper and structural steel. A comparison of sheabutter and grease mixed with graphite as lubricant for the drawing of aluminum rod was carried by Obi (1997). Also Obi, et al (1998) tested some of the oils, as drilling lubricants for mild steel. Earlier, Adeyemi's (1989) work had recommended the use of sheabutter as a replacement of the imported drawing lubricants for mild steel.

Suleiman (2011) Extraction and characterization of Senna-Tora (Tafasa) seed oil for engineering application. The result show that the lubricating and cooling properties of the oil is within the acceptable limit of IP/ASTM but cannot be used as fuel because of absence of combustible properties.

Çakīr, Kilickap (2007) Selection of cutting fluids for machining processes and the effects of workpiece material, cutting tool and machining process type. The result shows that the regeneration methods of used cutting fluids would also provide various advantages such as reducing cutting the fluids cost, disposals cost of used cutting fluids and nearly eliminating environmental pollution.

Patrick, Ganiyu (2011) Analysing the effect of cutting fluids on the mechanical properties of mild steel in a turning operation. His result shows that as cutting fluid is applied during machining operations, it removes heat by carrying it away from the cutting tool/workpiece interface.

Sharafadeen (2013) Performance Evaluation of Vegetable Oil-Based Cutting Fluids in Mild Steel Machining. It was established that ecology-friendly vegetable-based oils could successfully replace petroleum-based mineral oils as cutting fluids. With slight modifications and deliberate but careful alterations in some of the components of such oils, even better performing cutting fluids could be obtained.

Yuzan Yu, Yugao Guo (2010) Development of Environmentally Friendly Water Based Synthetic Metal-Cutting Fluid. The test results indicate that this cutting fluid has good cooling, cleaning, anti-rust, anti-corrosive and lubricating properties, is totally free of mineral oil, animal oil, nitrite that is harmful to the human body, phosphate that causes water pollution and etc., and has stable and reliable quality, long service life, easily available raw materials and low production cost.

Johnson and Emengo (2010) Formulation and Characterization of cutting fluids

The work demonstrated that the emulsion stability imparted by the petroleum sulphonate fractions to oil-water emulsions is dependent on the average molecular weights of the petroleum sulphonates.

CHAPTER THREE

MATERIALS AND METHODS

3.0 Introduction

The development and performance evaluation of cutting fluid from plant based oil (thevetia) and available additives is achieved by formulation and testing the ability of the developed cutting fluid to conduct heat away from the cutting zone and measurement of TPSF oil parameters. In order to establish its suitability as cutting fluids, the developed oil was compared with that of an established conventional cutting fluid (castor oil).

Table 3.1 Equipment and Materials

Equipment	Quantity measured
Soxhlet apparatus	extraction units
Extraction thimble	
Filter paper, whatman # 1, 11 cm	
Petroleum ether	Extraction reagent
pH meter (PH Meter s3510 JenWay).	pH
viscosimeter (Brookfield viscometer DV-E)	Viscosity
multimeter (MY-64).	Temperature
GCMS- QP2010 PLUS SHIMADZU, JAPAN	Fatty acid contents
UV spectrometer (HACH DREL/2400)	Chlorine
Pensey Martens flash point apparatus	Flash point
Titration apparatus	Fatty acid weight & Sulphur weight
Test tube, thermometer	Pourpoint

3.1 Method of Extracting Thevetia Pruvenssia Seeds Oil

3.1.1 Extraction of the TPSF oil

The seeds were first crashed using a grinding stone. A filter paper was folded in to a thimble shape and the sample was placed in thimble which was shaped in to a thimble holder. Add about 250ml of petroleum ether was added using glass funnel and the heater was switched on. When the petroleum ether began to boil, it was checked for any leakage by the sniffing around the ring clamp. Allow the extraction continued until all the oil was completely extracted.

3.1.2 Separation method

A mixture of petroleum ether and oil was heated so that the petroleum ether will be evaporated and collected in the condenser, and the oil was left in bottom of the flask.

3.2 Cutting Fluid Formulation and Characterization

For the preparation of the proposed fluid, the following steps were followed (ASTM D 974)

Mixing: 500ml of fixed oil was measured (using 1-litre measuring cylinder) and mix with water in oil to water ratio of 1:10 for 2 min. After all substances were added, they were mixed together for 15 min.

The cutting fluid developed will follow table 2.4

3.3 Measurement of oil parameters

3.3.1 Measurement of Density

The mass of known volume of oil sample was measured and the density of oil was calculated from: density = $\frac{mass}{volume}$

3.3.2 Specific gravity of TP Oil

The specific gravity of the oil can be calculated as: specific gravity = $\frac{density\ of\ the\ oil}{density\ of\ water}$

3.3.3 Measurement of absolute viscosity

The viscosity of the oil was determined using a ball viscometer (Brookefield viscometer DV-E) using ASTM D44-96. Kinematic viscosity is the ratio of absolute viscosity to the density of the oil.

3.3.4 Flash point of TP Oil

Flash point is the temperature at which sufficient inflammable vapour is given off by the fuel to cause a momentary flash when a flame is brought near its surface. The flashpoint was measured (ASTM) D93-94 (Pensey Marten flash point apparatus).

3.3.5 pH

The cutting fluid pH was determined using a digital PH meter (PH Meter 3510 JenWay).

3.3.6 Viscosity

A ball viscosimeter (Brookfield viscometer DV-E) was used to determine the viscosity of the cutting fluid.

3.3.7 Corrosion Test

This test involves in measuring the corrosion grade of cutting fluid by its contact with mild steel. Some grams of mild steel chips will be washed in acetone and dried, placed on a piece of filter paper in a Petri dish. The chips will be evenly spaced around the filter paper, prevented from contacting one another and humidified in 2ml of the test cutting fluid. The chips will then be left in the covered Petri dish for 2 hours. At the end of 2 hours, the mild steel chips will be discarded and the filter papers would be rinsed in acetone. The corrosion grade of the cutting fluid would be measured by observing how many spots appear on the filter paper surface. (Mijanovic,, 2001)

3.3.8 Fatty Acid Weight Measurement

Fatty acid weight was measured using British Standard Institute No.684. 1g of oil was weighed in a 250ml conical flask. 25ml of methanol was added followed by 2 drops of phenolphthalein indicator. The mixture was titrated with 0.1M NaOH solution until a light pink colour persists for about 1minute. The end point was recorded.

The fatty acid weight (F.A.W) was calculated as follows:

$$F.A.W=\frac{Titre*molarity\ of\ base*28.2}{weight\ of\ sample} \quad (5)$$

3.3.9 Pour Point (ASTM D4627)

A cylindrical test tube was filled with TPSF oil to a known level and clamped with a wooden clamp bearing thermometer. The sample was allowed to cool below 0ºC in ice/salt bath. It was then removed and tilted on the clamp. The setup was observed at regular interval. The lowest temperature at which the oil begins to flow was recorded. This gives the pour point of the oil.

3.3.10 Chlorine Weight

Chlorine weight was measured with UV spectrometer (HACH DREL/2400)

Chlorine in the sample as hypochlorus acid or hypochlorite ion immediately reacts with DPD (N,N-diethyl-phenylene diamine) indicator to form a pink colour, the intensity of which is proportional to the chlorine concentration. The test results are measured at 530nm.

3.3.11 Active sulphur and sulphur weight

Materials and reagents: Standard $BaCl_2$ solution (1ml=0.0004gram of sulphur), 0.02MKOH, 0.02MHCl, phenolphthalein indicator, Tetrahydroxyquinone (dipper) indicator, ethyl alcohol.

Procedure: 0.8g of oil sample was weighed and sparked with oxygen. The sample obtained was treated with bromine water. The resulting solution was subjected to evaporation to remove excess water present and the then cooled.25ml of the solution was pipette to the flask. A few drop of phenolphthaline was added followed by KOH. A red colour solution was formed and this was discharged by adding HCl. 25ml of alcohol and a dipper of indicator was added. The resulting solution was titrated with $BaCl_2$ solution until the solution changes sharply from yellow to red that is permanent with strong shaking.

(Robert .T sheen and H. Lewis)

Amount of sulphur present is given as

$$\frac{\text{ML of BaCl2 x stenght of BaCl2(in grams of sulphur per ml)}}{\text{weight of oil sample in gram}} \text{ x100x4}$$

3.3.12 Fatty acid contents

Fatty acid contents were measured with GCMS- QP2010 PLUS SHIMADZU, meter.

3.3.13 Emulsion stability (ASTM D 974)

After the oil and its additives are mixed, the mixture will be allowed to repose for 24 hours to check for the level of emulsion.

3.4 Mechanical Performance Evaluation

3.4.1 Turning operation

A turning operation of medium carbon steel was performed on a centre lathe with speed range of between 90 rpm and 1000 rpm but using five different speeds (90, 120, 140, 180,224rpm) A depth of cut of 2 mm was selected and chips produced were collected.

The thicknesses of the chip produced were measured using a micrometer screw gauge and the corresponding chip thickness ratios were calculated. The chip thickness ratio is the ratio of the chip thickness to the depth of cut.

$$\text{Chip thickness ratio} = \frac{\text{chip thicness(tc)}}{\text{depth of cut (dc)}} \quad \text{---(5)}$$

During the turning operation the cutting temperature was measured using multimeter (MY-64).

3.4.2 Technique for Measuring Temperature

The multimeter was put on. The meter knob was set to temperature calibration; the thermocouple was fixed on the temperature slot. The tip of the thermocouple was fixed to the cutting edge of the cutting tool. This measures the temperature during turning operation.

CHAPTER FOUR

RESULTS

4.1.1 Measurement of Viscosity

The viscosity of the oil was measured at two different set temperatures as shown in table1.0

Measurement of viscosity at 40^{o}C

Viscometer model…………………………………Brookfield viscometer DV-E

Spindle code No…………………………………..061

Rotational speed………………………………….50rpm

Container size…………………………………….250ml beaker

Ambient temperature…………………………….29^{o}C

Spindle rotation time…………………………….2minutes

Guardleg……………………………………….Not used

Date…………………………………………….20/02/2013

Readings……………………………………….24.68, 24.70, 24.70

Average viscosity…………………………….. $\frac{24.68+24.70+24.70}{3}$ =24.69cp

The viscosity of the oil is 0.0247Ns/m^2

Measurement of viscosity at 100°C

Viscometer model…………………………………Brookfield viscometer DV-E

Spindle code No…………………………………..061

Rotational speed………………………………….50rpm

Container size…………………………………….250ml beaker

Ambient temperature…………………………….29°C

Spindle rotation time…………………………2minutes

Guardleg……………………………………….Not used

Date……………………………………………20/02/2013

Readings……………………………………….9.10, 9.00, 9.10

Average viscosity…………………………….. $\frac{9.10 + 9.00 + 9.10}{3}$ =9.08cp

The viscosity of the oil is 0.0091Ns/m^2

Table4.1 Viscosity of TPSF at set temperature

Temperature(°C)	Viscosity(cp)	Viscosity(cSt)= viscosity(cp)/density of oil
40	24.69	29.50
100	9.08	10.85

Table 4.2 Comparison of properties of conventional soluble oil and TPSF

Properties	Conventional soluble oil (ConocoPhillips Company, 2011)	TPSF
Specific Gravity @ 60ºF	0.919	0.837 *
Density lbs/gal @ 60ºF	7.65	6.98 *
Flashpoint ºC	184	98 **
Pour point ºC	-43	-1 **
Viscosity		
cSt @ 40ºC	34.2	29.5 ***
cSt @ 100ºC	5.0	10.8 ***
Viscosity Index	51	15.33
Emulsion Stability	Good	Good *
Iron chip corrosion test	Pass	Pass *
Ph	10.3	7.71 ***
Chlorine, wt %	Nil	0.16 ****
Fatty oil, wt %	Nil	5.64 **
Sulphur, Total,wt %	0.43	Nil **
Sulphur, Active, wt%	Nil	Nil **

* Al-azhar School laboratory, Kano

** Chemical Engineering Dept, A.B.U Zaria.

*** Instrument Laboratory, chemistry department, B.U.K

**** NARICT, Zaria

Table4.3 Fatty acid composition of TPSF oil

Fatty acid	Chain length	Type of bond	Percentage composition
Palmitic	16	1	36.72
Nonadecylic	19	1	5.11
Oleic	18	2	50.49
Stearic	18	1	7.67

4.1.2 pH Measurement

The pH of TPSF was found to be 7.71

4.1.3 Corrosion Measurement

A filter paper was washed with acetone. The metal chips were evenly separated on the filter paper then humidified with the cutting fluid solution. Out of 10 chips used, 3 spots were found to be reddish brown.

4.1.4. Measurement of sulphur

Following the adopted procedure, no colour change was observed at the end of titration. This indicates that no sulphur in the oil sample.

Table 4.4: Formulation table for TPSF Oil

Material	Function	Content (%) volume/volume
Plant oil (thevetia seeds)	Base oil	75
Washing soap	Emulsifier	15
Phenol	Disinfectant	5
Sulphur	Extreme pressure agent	5

Table 4.5 Chip thickness and Chip thickness ratio

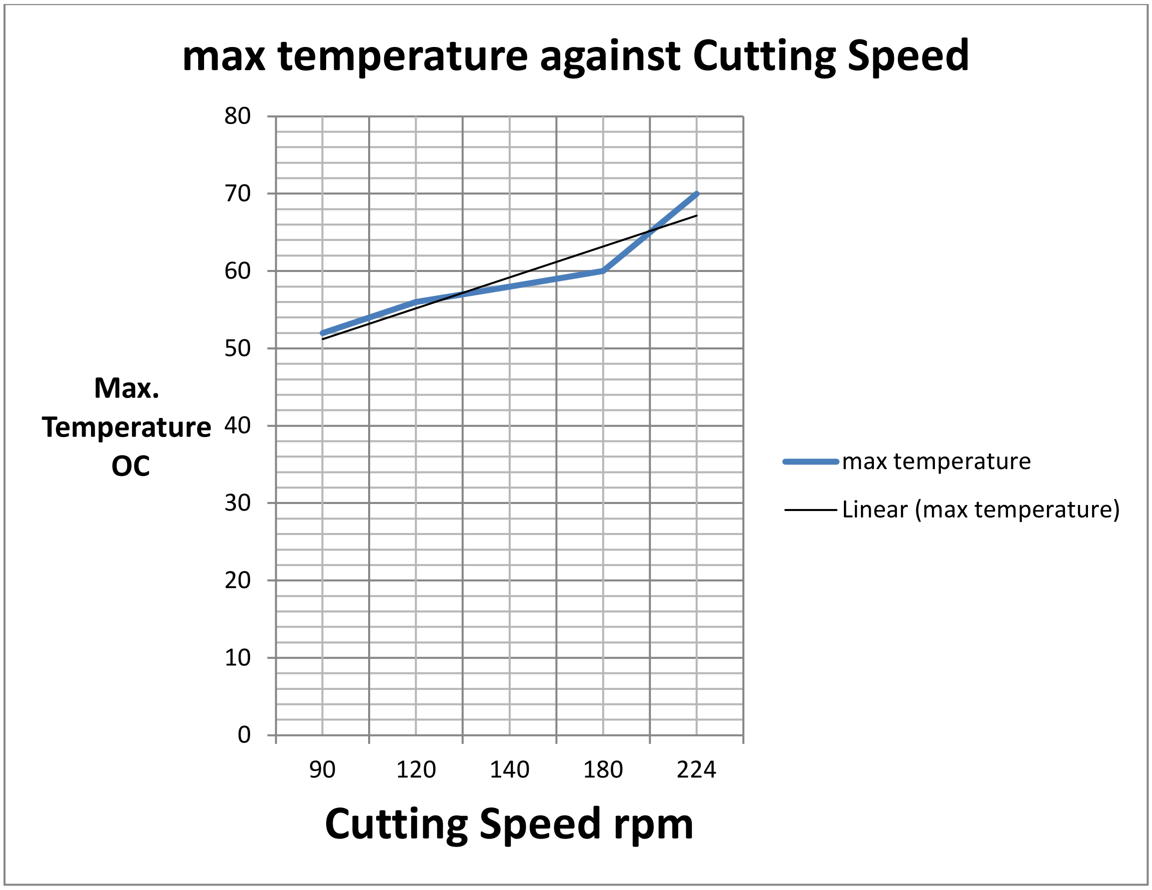
Depth of cut, d=2mm

S/N	Cutting speed/rpm	Chip thickness, t_c/mm	Chip thickness ratio, r (t_c /d)
1	90	0.16	0.080
2	120	0.17	0.085
3	140	0.17	0.085
4	180	0.18	0.090
5	224	0.20	0.100

Table4.6 Temperature during turning operation using (TPSF) fluid and castor oil.

S/N	Cutting speed/rpm	Maximum temperature(°C) (TPSF oil, T)	Maximum temperature(°C) (Castor oil, T_c)	$\frac{T - T_c}{T_c}$ %
1	90	52	51	1.96
2	120	56	54	3.7
3	140	58	62	-6.5
4	180	60	65	-7.7
5	224	70	68	2.9

Fig 2.0: maximum temperature against cutting speed for developed TPSF cutting fluid



4.2 Discussion of Results

4.2.1: Viscosity

The viscosity of TPSF measured at 40ºC is 29.50cSt which is lower than that of soluble oil by 16%. The viscosity of TPSF measured at 100ºC is 10.85cSt which is higher than the soluble by 54%. This shows that TPSF can retain its viscosity at a higher temperature than the soluble oil. In general, the low viscosity of TPSF means that it will have less lubricating capability. There is therefore need for additive to increase its viscosity.

4.2.2: pH Value

The pH of the TPSF fluid was found to be 7.71compared to that of soluble oil of 10.3 which is an advantage because it is less corrosive**.**

The pH value of the TPSF makes it suitable for use in machining operations involving mild steel.

4.2.3: Corrosion

Maximum of three spots were observed in the corrosion test. This indicates that the corrosion level of TPSF is vestiges (Mijanovic, 2001)

4.2.4: Fatty acid test

The presence of unsaturated acid (oleic acid) which constitute a major component of the acid in the oil enhance the lubricity of the oil. This is because it can react easily to form a film of adherent layers which adhere to the surface of the metal thereby preventing direct metal to metal contact.

4.2.5: Free fatty acid test of TPSF

The presence of free fatty acid (5.64%) in the oil determines its stability. This shows that the oil can be stored for a long period of time without spoil.

4.2.6: The flashpoint of TPSF

The flashpoint of TPSF (98ºC) shows that it is less hazardous to the operator and the environment. However, it is much lower than that of conventional oil which has flash point of 184ºC.

4.2.7: Pour point of TPSF

TPSF has a pour point of -1ºC. This makes it unsuitable to use in cold temperate region but it is suitable for use in tropical countries like Nigeria.

4.2.8: Chlorine test of TPSF

A chlorine content of 0.16 wt% was obtained compared with conventional oil with no chlorine content. The presence of chlorine acts as an antiseptic agent and it increases the emulsion life of the base oil

4.2.9: Sulphur test of TPSF

TPSF has no sulphur content as compared with the conventional oil with.43wt%. The absence of sulphur is an advantage because of the corrosiveness of its compounds.

4.2.10: Cooling Properties of TPSF oil

From table 4.6, it is observed that both fluids have similar ability to control temperature (i.e conduct heat away from the cutting zone). The least percentage difference in temperature exists at 180rpm.

4.2.11: Chip thickness ratio

Chip thickness ratio increases with cutting speed. The low value of chip thickness ratio shows the better performance of the TPSF fluid (Oxford, 2001)

CHAPTER FIVE

5.0 CONCLUSIONS

Oil has been successfully extracted from TPS and has been characterized with the following results:

1. TPSF oil has similar ability to conduct heat away from the cutting zone when compared with the castor oil.
2. TPSF oil has pH value of 7.71 which shows that it has much lower tendency to corrode metal than castor oil with pH value of 10.3. The corrosion test confirms its level is low.
3. The viscosity of TPSF oil at 40ºC is lower than that of castor oil by approximately 16% but at 100ºC the viscosity of TPSF is 54% higher than that of castor oil.
4. The presence of chlorine (0.16wt%) shows that TPSF can acts as an antiseptic agent and it increases the emulsion life of the base oil.
5. The flashpoint of TPSF (98ºC) which is about half of castor oil with 184ºC which means it is not as good as castor oil.
6. TPSF has high pour point (-1ºC) which is higher than that of castor oil which is -43ºC. This makes it unsuitable for use in cold temperate region but it is suitable to use in tropical countries like Nigeria.
7. TPSF oil has no sulphur content compare to castor oil which has total content of 0.43wt.

On the bases of the result of the research work, the aim of the work has been achieved.

5.1 RECOMMENDATIONS

1. With a view to improve some of its properties, further research should be carried out with TPSF oil so that we might be self-reliant in providing cutting fluid for engineering application.
2. A viscosity index improver is needed to boost the viscosity level of TPSF oil.

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APPENDIX

Table 5.1: free acid, saponification, iodine, phosphorus values and the viscosity of local oil (ajala, 1981)

Lubricant	***% free acid***	**Saponification value**	**Iodine value**	**%phosphorus**	**Viscosity at 27^0c**
Palm oil	6.99 -31.99	225.41-227.56	64.5	0.048	245
G/Nut oil	0.11-0.24	223.04-230.23	106.10	0.067	225
Palm kernel	4.63	286.95	18.67	0.065	191
Shear butter oil	0.60-.69	167-177.7	68.2-68.7	-	257
Golden soya	3.0	189-165	120-141	0105	-
Cotton seeds oil	0.11-.32	221.39-22.56	111.15	-	-

GLOSSARY

absolute viscosity	The resistance to flow encountered when one layer or plane of fluid attempts to move over another identical layer or plane of fluid at a given speed. Absolute viscosity is also called dynamic viscosity.
centipoise	A unit of measurement for absolute viscosity equal to one-hundredth of a poise. One centipoise is equal to the millipascal second, one-thousandth of a pascal second.
centistoke	A unit of unit millimeters squared measurement for kinematic viscosity equal to the per second. The centistoke is the ratio of a liquid's absolute viscosity in centipoise to the density.
corrosion	A process by which a metal degrades from a reaction with a chemical such as an acid.
kinematic viscosity	The ratio of a fluid's absolute viscosity to its density, or the absolute viscosity divided by the density. Kinematic viscosity is the most

common viscosity measurement.

flash point	The temperature at which the hydraulic fluid surface emits enough vapor to ignite in the presence of a flame.
pour point	The temperature at which a fluid begins to flow.
viscosity	A hydraulic fluid's resistance to flow. As temperature increases, viscosity decreases.
viscosity index	A number describing how the viscosity of a fluid changes with temperature. Fluids affected by temperature extremes have a low viscosity index, while fluids that maintain viscosity have a high viscosity index.