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"A Experimental Analysis Of Minimum Quantity Lubrication By Sunflower oil and Neem Oil as cutting fluid"

Prashant Kumar Soni, Prof. Suresh Kumar Badholiya
*[1]Mechanical , RGPV/Bhopal Institute Of Technology & Science ,Bhopal,M.P., INDIA

*[2]Mechanical , RGPV/Bhopal Institute of Technology & Science ,Bhopal,M.P., INDIA

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ABSTRACT: Cutting fluids are used to reduce the negative effects of heat and friction on the tool and the work piece. The unique cutting fluids have three effects on heat removal from the process, The use of vegetable oils allows high performance in machining combined with good compatibility with the environment that is achieved. Compared to mineral oil, vegetable oil can even improve cutting performance, prolong tool life and improve surface finish. Although many environmental benefits, vegetable oils are more susceptible to degradation by oxidation or hydrolytic reactions.The use of cutting fluids less harmful to the semi-dry lubrication technique that uses a large amount of cutting lubricants. Several researchers have already been carried out in this area, which are inevitably prior to vegetable oil as a coolant / lubricant in different machining operations .Vegetable oils are not toxic to the environment; these types of fluids are renewable and have a high biodegradation capacity

KEYWORDS:MQL,cuttingfluid,coolent, lubricant, MQCL

I. INTRODUCTION

Nowadays, manufacturing industries are the chief wealth producing sectors where machining plays a vital role. In machining, most of the energy supplied to the machine tool is converted into heat. When different materials are machined, increase in machining speed will increase the temperature and decrease the tool strength which leads to tool failure. For higher productivity, high cutting speed is desirable but due to high temperature, faster tool wear will limit the cutting speed. Thus temperature at the cutting zone needs to be cooled down. To deal with the heat generated during machining, Cutting fluids are used to reduce the negative effects of heat and friction on the tool and the work piece. The unique cutting fluids have three effects on heat removal from the process, lubrication at the chip-tool interface and chip removal. However, the advantages caused by cutting fluids have been questioned lately, due to the several negative effects they cause on the environment and on the worker's health. When discharged improperly, cutting fluids can damage soil and water resources, causing serious environmental impacts. On the shop floor, machine operators can be affected by the negative effects of cutting fluids, such as breathing and skin problems. For these cases, alternative solutions are developed to avoid the environment and health.

The use of vegetable oils allows high performance in machining combined with good compatibility with the environment that is achieved. Compared to mineral oil, vegetable oil can even improve cutting performance, prolong tool life and improve surface finish.Although many environmental benefits, vegetable oils are more susceptible to degradation by oxidation or hydrolytic reactions.

Machining is the removal of unwanted material from the work piece in the form of chips. In order to get a finished product with the desired shape, this is usually done using machine and cutting tools. The growing demands of industries for high machining productivity require high removal rates, which use a high cutting speed and feed rate, but a high removal rate leads to increased surface roughness and tool wear. Thus, the cutting environment is identified as a critical reason for producing a surface finish and also extending tool life. There are several types of metal cutting fluids that are classified as pure fluid, synthetic fluid and semi-synthetic fluids, soluble fluids and vegetable based cutting fluids. Petrochemical and synthetic cutting fluid has many negative effects [1]. FIG. 1 shows the adverse effect associated with the use of metal working fluid These are hostile to the environment and toxic in nature. The use of cutting fluids less harmful to the semi-dry lubrication technique that uses a large amount of cutting lubricants. Several researchers have already been carried out in this area, which are inevitably prior to vegetable oil as a coolant / lubricant in different machining operations .Vegetable oils are not toxic to the environment; these types of fluids are renewable and have a high biodegradation capacity. Biodegradable and renewable oil because it is proven to be an agricultural product. Without harmful additives unlike the petroleum product, the use of EP additives, such as chlorine and sulfur [3].

They also have good lubricity. In addition to the cooling action, the cutting fluid also lubricates a machining zone, the first cutting ones available These are hostile to the environment and toxic in nature. The use of cutting fluids less harmful to the semi-dry lubrication technique that uses a large amount of cutting lubricants. Several researchers have already been carried out in this area, which are inevitably prior to vegetable oil as a coolant / lubricant in different machining operations .Vegetable oils are not toxic to the environment; these types of fluids are renewable and have a high biodegradation capacity.

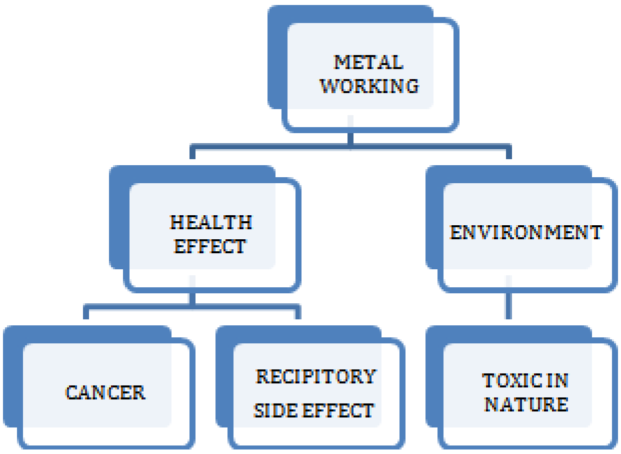

Figure 1.1 CCF Effect in Worker Health and Environment

Biodegradable and renewable oil because it is proven to be an agricultural product without harmful additives unlike the petroleum product, the use of EP additives, such as chlorine and sulfur. They also have good lubricity. In addition to the cooling action, the cutting fluid also lubricates a machining zone, the first cutting ones available.

1.1 Cutting fluids:

Cutting fluid, as a component of machining industry, has been introduced and applied over 100 years. Cutting fluids are used in metal machining for a variety of reasons such as improving tool life, reducing work piece and thermal deformation, improving surface finish and flushing away chips from the cutting zone.

1.2 Classification of cutting fluids:

Practically cutting fluids are classified into four categories:

a. Straight oils
b. Soluble oils
c. Semi synthetic fluids
d. Synthetic fluids

1.2.1 Straight oils:

Straight oils are non emulsifiable. These oils in undiluted form are used in machining operations. 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 phosphorous. Straight oils provide the best lubrications and poor cooling characteristics among cutting fluids.

1.2.2 Synthetic fluids:

Synthetic fluids are formulated from alkaline inorganic and organic compounds along with additives for corrosion inhibition. They are generally used in a diluted form. Synthetic fluids provide the best cooling performance among all cutting fluids.

1.2.3 Soluble oil fluids:

Soluble oil fluids when mixed with water form an emulsion. The concentrate consists of emulsifiers

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and base mineral oil to help produce a stable emulsion. They provide good lubrication and heat transfer performance. They are the least expensive among all cutting fluids.

1.2.4 Semi synthetic fluids:
Semi synthetic fluids are combination of soluble oil fluids and synthetic fluids. They have characteristics common to both types.

1.3 Basic functions of cutting fluids:
The basic functions of cutting fluids include the following four considerations: cooling, lubrication, corrosion protection and chip removal.

1.3.1Cooling:
It is known that the energy generated in metal cutting operation both through deformation and the sliding friction appears to be thermal energy or heat. This high temperature can usually shorten the fool life, cause an undesirable surface finish and bring down the cycle time due to the reduction of cutting speed. This cutting fluid acts as coolant and reduces the heat generated.

1.3.2 Lubrication:
It is believed that due to high pressure and relatively high temperature in most cutting operations, liquid film cannot be sustained along tool/work piece interface for all the time. Thus the conditions in a typical cutting process are believed to approach boundary lubrication. This can be achieved by cutting fluids.

1.3.3 Corrosion protection:
A good cutting fluid protects the work piece from corrosion damage.

1.3.4 Chip removal:
The fourth major function of cutting fluid in machining process is to remove chips from the cutting zone. And the fluid will also prevent the machined surface from being scratched by chips.

1.4 The Desirable properties of cutting fluids in general:

a. High thermal conductivity for cooling
b. Good lubricating qualities
c. High flash point should not entail a fire hazard
d. Must not procedure a gummy or solid precipitate at ordinary working temperatures
e. Be stable against oxidation
f. Must not promote corrosion or dislocation of the work material
g. Must afford some corrosion protection to nearly formed surfaces
h. The components of the lubricant must not become rancid easily
i. No unpleasant odor must develop from continued used
j. Must not cause skin irritation or contamination
k. A viscosity that will permit free flow from the work and dripping from the chips.

1.5 Characteristics of cutting fluids:
A good cutting fluid could be listed as:

a. Good lubricating qualities to reduce friction and heat generation
b. Good cooling action to dissipate the heat effectively that is generated during machining
c. Effective anti-adhesion qualities to prevent metal seizure between the chip and the rake face
d. Good wetting characteristics which allow the fluid to penetrate better into the contact areas as well as in the cracks.
e. Should not cause rust and corrosion of the machine components
f. Relatively low viscosity fluids to allow metal chips and dirt to settle out
g. Resistance to rancidity and to formation of a sticky or gummy residue on parts or machines
h. Should be economical in use, filter and dispose.

1.6 Process effects of using cutting fluids in machining include:

a) Longer tool life
b) Reduced thermal deformation of work piece
c) Better surface finish
d) Ease of chip and swarf handling

1.7 Factors to be considered while selecting Cutting Fluids:

1.7.1 **Types of work piece materials:**
Cutting fluids used, should provide easy machining operation in all materials. Ferrous metal are brittle in nature and hence during machining they break into small size chips. The friction between cutting tool and chip is less due to small size chip formation. It was proposed that using emulsion cutting fluids increases surface finish quality and prevents dust formation during machining. During machining operation of, generally the high pressure containing and additive cutting fluids are used. In stainless steel machining, high pressure cutting oils should be selected. Work-hardening properties in some steels would cause some problems during machining operation. For machining of heat resistant and difficult-to-cut steel alloys, water based cutting fluids are preferred, because temperature becomes higher in cutting area. During machining of

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aluminium and aluminium alloys, high temperatures do not occur Waterless cutting fluids prevent the formation of ―built up edge‖, however this type of cutting fluids must be non-active. Machining of copper and copper alloys poses similar problems. The application of emulsion cutting fluids or thin mineral oils should be selected for copper and copper based alloys machining. High pressure additive cutting oils are preferred for brass machining. In the machining of nickel and nickel alloys, the machining operation should be carried out as dry or using cutting fluids. Higher cutting speeds and feed rates should be selected when cutting fluids are used in the machining of these materials. Generally sulphured mineral oil as cutting fluid is preferred.

1.7.2 Types of cutting tool material:

The other influential parameter for selection of cutting fluid in machining processes is the cutting tool material. Different cutting tool materials are commercially available for carrying out different machining operation. High speed steel cutting tools can be used with all type of cutting fluids. However waterless cutting fluids are preferred when difficult-to-cut materials
are machined. In case of the tungsten carbide (WC) cutting tools application, more cooling characteristics from cutting fluids are required. This is because of high generated heat in the interface of cutting tool and work piece material. The negative effect of generated heat during machining with WC cutting tools causes rapid tool wear. Hence toll life will be shorter and surface finish quality falls.

1.7.3 Vegetable based cutting fluid:

A ―Vegetable oil‖ is a triglyceride extracted from a plant. Vegetable oils that are solid at room temperature are sometimes called vegetable fats. Vegetable oils can be classified in to various ways depending upon the source, application etc.., oils can be edible or non-edible in nature. Compared to mineral oils vegetable oils in general possess high flash point, high viscosity index, high lubricity and low evaporative losses. Vegetable oils are extracted from plants by placing the relevant part of the plant under pressure, to squeeze the oil out. Oils (edible or non- edible) may also be extracted from plants by dissolving parts of plants in water or another solvent, and distilling the oil, or by infusing parts of plants in base oil. Various researchers have proved the worth of edible vegetable oils viz., coconut oil, palm oil, soya bean oil, canola oil to be used as eco-friendly fluid in recent past. But in present situations harnessing edible oils for lubricants formation restricts the use due to increased demands catering the growing population worldwide and local availability. Non-edible vegetable oils and other tree borne seeds can prove to be an effective alternative, although limited research has been done on varieties like PongamiaPinnata (karanja), Jatrophacurcas (Ratanjyot) etc., prominently for biofuel applications and needs focused attention for fulfilling the environmental friendly lubricant need their full potential. Castor, Mahua and Neem also process certain properties which makes them a promising candidate for such formulations. Non-edible vegetable oils are renewable and biodegradable in nature.

1.8 Applications of vegetable oils:

Vegetable oils are used as an ingredient (or) component in many manufacture products. These oils are particularly suitable as drying oils, and are used in making paints and other wood treatment products. Vegetable oils are increasingly being used in the electrical industry as insulators. As vegetable oils are not toxic to the environment, biodegradable if spilled and have high flash and fire points. However, vegetable oils are less stable chemically, so they are generally used in systems where they are not exposed to oxygen. Vegetable oil is being used to produce biodegradable hydraulic fluid and lubricant.

1.8.1 Edible oils:

A liquid fat that is capable of being eaten as a food or food access, like Coconut, Olive, Soya bean, Sunflower, Palm, Peanut, Rapeseed, Corn etc. Various countries import edible for their food requirements. India is the biggest importer of edible oils in the world. Approximately,
16.6 million tons of edible oils consumed each year in India. Therefore, edible oil seeds usage for lubricant needs may not be able to meet domestic requirements for ever increasing population.

1.8.2 Non edible oils

As an alternative non-edible vegetable oil and tree borne seeds can prove to be worthwhile. These products from non-edible vegetable oils like Neem, castor, Mahua, rice bran, karanja, Jatropha, and linseed oils which offer better or at least same performance as petroleum oil based products besides being less expensive [8, 9]. Non edible vegetable oils are technically and environmentally acceptable and easily available resource for bio lubricants.

1.8.3 Current Status — Non Edible Vegetable Oils:

Being a tropical country, India is rich in forest resources having a wide range of trees, which yield a significant quantity of oilseeds. India is importing crude petroleum & petroleum

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1.9 Machining Process

Machining is a process designed to change the size, shape, and surface of a material through removal of materials that could be achieved by straining the material to fracture or by thermal evaporation. Machining offers important benefits such as:

a. Excellent dimensional tolerances
b. Sharp corners, grooves, fillets, various geometry
c. Surface finish

1.9.1 Machining operations:

The three principal machining processes are classified as turning, drilling and milling. Other operations falling into miscellaneous categories include shaping, planning, boring, broaching and sawing.

1.9.2 Turning operation:

Turing operations are operations that rotate the work piece as the primary method of moving metal against the cutting tool. Lathes are the principal machine tool used in turning

1.9.3 Milling operation:

1.10 Reducing adverse effects of Cutting Fluids on Environmental:

1.10.1 **Dry Machining:**

Dry machining means that no cutting fluid is used during process. For economic as well as environmental reasons machining process is carried out without any cutting fluid. Some work piece materials presents many problems during dry machining like Aluminium, which is a soft material. Dry machining of Aluminium induces influences on the surface quality of the work piece. Higher friction between tool and work piece in dry machining can increase the temperature in cutting region. In milling cutting, tool does not cut continuously and the using of cutting fluids increase thermal shock effect. Hence, dry machining is better suited for milling operations. In drilling, especially gun drilling the most important function of cutting fluid is the chip removal and dry cutting may induce drill breakage.

1.10.2 Minimum Quantity of Lubrication (MQL):

Due to economic, ecological and technical reasons, at present it is attempting to reduce the use of oils and cutting fluids in metal cutting. The first option is dry machining, but in many cases this is impossible due to the nature of the work piece materials. During machining, many nonferrous alloys, and especially aluminium, tend to be adhered to tool edges, giving rise to complex problems like the wrong cutting of the work piece material and leading to a high tool wear. In this case, an interesting option is the use a lubrication/coolant system based on the injection of pressurized air with small quantities of oil. This technique is designated MQL (Minimum Quantity of lubrication). In MQL the chip, work piece and tool holder have a low residue of lubricant thus their cleaning is easier and cheaper as compared to flooding of cutting fluid. The cutting region is not flooded in MQL during machining so the operation can be seen by the operator. MQL is used as a lubricating method rather than cooling. This poor cooling capacity limits the effectiveness of MQL in machining of difficult-to-machine materials such as titanium and nickel based alloys due to the excessive heat generation. Several experimental studies have investigated for the performance of MQL in the drilling, turning, milling and grinding processes. The most literature studies compared the performance of MQL with dry cutting and flood application. The overall performance (cutting force, tool life, surface finish, cutting ratio, cutting temperature and tool-chip contact length) during MQL was found to be superior to dry and conventional wet turning of hardened steel. The problem is that the mineral based oil is poor in biodegradability and thus it's potential for long term pollution of the environment and workers health. The growing demand for biodegradable materials has opened avenue for using vegetable oils as an alternative to conventional cutting fluids

II. LITERATURE REVIEW

N. Anand, S. Senthil Kumaran [2020] [1] Mineral oils are widely used in manufacturing industries as lubricants during machining operation. But it is not environment friendly and it is not sustainable. So researchers have paved the way for using vegetable oils as substitutes for mineral oils and have discovered some great results. This article reviews some important research papers that have used vegetable oils and their effect on surface finish and shear forces. The most important advantages of vegetable oils are their availability, sustainability and, most importantly, the risk related to the health of the machine operator is reduced. The main vegetable oils discussed in this document are coconut oil, jatropha oil, Pongamia oil, sesame oil, sunflower oil, and castor oil. The properties of these oils and the behavior of these oils in the machining environment are critical. Therefore, it is gaining a lot of attention in the area of tribology, which deals with friction, wear, and lubrication.

Viswanathan et.al, 2018 [2] The turning operation was performed on the magnesium alloy using the tungsten carbide cutting tool with dry lubrication and in minimal quantity per. Minimum

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quantity lubrication conditions are best for optimizing performance for cutting forces, cutting temperature, tool wear, and surface roughness.

S. Shankar, T. Mohanraj *, K. Ponappa [2017] [3] Due to environmental and health concerns, there is a huge need to develop new cutting fluids (CF). Vegetable Based Cutting Fluid (VBCF) is environmentally friendly, decreases harmful effects to the operator, and also improves machining performance such as surface roughness, tool life, minimal vibration, and shear forces. In this work, the yields of four different VBCFs such as palm oil, coconut, sunflower, soybean and a commercial type of CF were considered to analyze the influence of cutting fluids when measuring cutting force and vibration signatures during Grinding 7075-T6 hybrid aluminum metal matrix composite with carbide insert tool. The experiments were carried out on the L-MILL 55 CNC vertical machining center, with milling tool dynamometer to measure cutting force and a triaxial accelerometer to measure vibration signals. The flow rate of the VBCFs was kept at a constant rate and the results were compared with a commercial cutting fluid. The result obtained shows that palm oil is better suited than other vegetable-based cutting fluids in terms of minimum required cutting force and minimum vibration. Furthermore, the experimental result shows that the cutting fluid was one of the important parameters to consider that influences the cutting force and the vibration signals.

Maheswara Reddy et.al, 2016 [4], analyzed the surface roughness of Inconel 718 for turning operations with the help of a minimal amount of lubrication. The surface roughness of the machined work material during (Ws2) solid lubricant assisted with a minimal amount of lubrication and the results show that approximately 35% was increased compared to the minimal amount lubrication machining alone. Solid lubricant (Ws2) can function effectively as an additive for oil-based cutting fluid [11].

Samatham Madhukar *, Aitha Shravan [2016] [5] Cooling lubricants and cooling systems have various tasks in metal cutting. They mainly conduct heat and reduce friction. They ensure a uniform temperature of the workpiece and the tool and help to maintain tolerances. The supply, preparation, and disposal of cooling lubricants can be costly. Furthermore, these substances pollute the environment. Therefore, it is worth thinking about alternatives. One possible solution in the search for the optimal lubrication system is minimum quantity lubrication (MQL), which is increasingly important. This is an alternative between wet and dry machining. In the case of a minimal amount of lubrication, the amount of lubricant applied is reduced to a minimum. The maximum volumetric flow rate with MQL is less than 50 ml / hour. Compared to conventional wet machining, where up to 12,000 liters of coolant are used per hour and must be reconditioned again, the user of the MQL system does not need more than a few milliliters. Optimal lubrication considerably reduces frictional heat. With MQL, machining costs can be greatly reduced. The environment is also protected and possible risks to the health of the machine operator are reduced. The current article reviews different types of MQL systems, comparison of MQL cooling system with conventional cooling systems, applications and advantages of MQL cooling system Mohammadajafar et.al, 2016 [6]. An experiment was carried out comparing both dry and fluid milling process based on temperature distribution and surface integrity of the workpiece. Research on the MQL technique has shown better results and good lubrication in the grinding process. The results show that there is a better heat transfer and the temperature at the contact point remains the same [12]. The grinding operation was carried out with different lubrication and different cooling conditions for the ABNT 4340 steel by Silva et.al, 2015. The tangential shear force was reduced using minimum quantity lubrication (MQL) with convection cooling condition [13].

Nourredine Boubekri et.al, 2015 [7], gives us a review on the lubrication of minimum quantities, the health benefits of lubrication of minimum quantities and its future research.

J. B. Shaikh [2014] [8] in his work determined the influence of lubricant on surface roughness and material removal rate (MRR) by using CNC lathe machine with AISI D2 Steel. Taguchi method it was used to determine and optimize operational parameters. The above experimentation results help professionals to compare and increase MRR, the surface finish using a more environmentally friendly oil as a lubricant.

Ibrahim et al., 2014. [9] The effects of six different strategies on different properties were studied in the turning of titanium alloy with MQL dry vegetable oil, MQCL vegetable oil, cooled air, flooding, cryogenic are the six different strategies analyzed , MQL was found to be the best alternative in terms of surface finish, tool wear, energy consumed [5].

Hasan et.al, 2014 [10], talks about the effects of MQL with vegetable oil as a cutting fluid compared to dry and wet machining. The results show that chip tool interface temperature, tool wear and surface finish have provided better properties with the use of MQL compared to wet and dry machining.

Amit et.al, 2014 [11] analyzed the turning operation in AISI -4340 alloy steel using a minimum amount of lubrication for different machining parameters such as cutting force, surface roughness and tool wear. The cutting performance of the MQL technique is better than that of dry and conventional machining. After using MQL technique, tool life gradually increases, surface finish, and cutting fluid waste can be further reduced [14].

Lawal, [2013] [12] studied the cutting fluids that consist of a simple oil applied with brushes to cool and lubricate the machine tool. However, the formulation of the cutting fluid became more complex as the cutting operation became more severe. In this article, the focus is on recent research work on the application of vegetable oil-based cutting fluids in non-ferrous metal machining. The results obtained established that vegetable oil-based cutting fluids are good fluids for metalworking.

Babur OzcelikEmel kuram, 2013 [13] focused on both the formulation of vegetable-based cutting fluids and machining with these cutting fluids. For this, the characterization of the chemical and physical analyzes of these cutting fluids is carried out Experimental results show that canola-based cutting fluid offers the best performance due to its superior lubricating properties over other cutting fluids with constant cutting conditions.

Prasad et.al, 2013 [14], demonstrates the use of nano fluids in a minimal amount of lubrication to rotate the operation. MQL-assisted machining provided better performance compared to dry machining. MQL provided better performance in terms of surface roughness, tool wear, temperatures and other properties such as biodegradability and microbial contamination have been reduced.

Kalita et al., 2012 [15] studied the impact and lubrication mechanisms of advanced nanolubricants, consisting of organic molecules with phosphide-intercalated MoS_2 nanoparticles (<100 nm), in the MQL surface grinding of ductile cast iron. It is observed that the efficiency of nano lubricants, a 45-50% decrease in the force ratio and specific energy, and a 48-55% decrease in abrasive wheel wear, compared to grinding with cooling by conventional flooding and MQL with lubricant paraffin (base). Nanoparticles entrapped in porous abrasives and tribochemical film formation of a Mo-S-P chemical complex on friction surfaces during grinding, thereby reducing friction. These tribological mechanisms correlate with the friction, energy, and wear-reducing efficiency of the nanolubricants wheels during grinding.

III. PROPERTIES OF BIO OIL

3.1 Selection of Bio-Oils:

Cutting fluids are used to reduce the negative effects of the heat and friction on both tool and work piece. The cutting fluids produce three positive effects in the process heat removal, lubrication on the chip-tool interface and chip removal. However, the advantages caused by the cutting fluids have been questioned lately, due to several negative effects they have caused in the environment and worker health. 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 these cases alternative solutions are developed to avoid environment and health.

The use of vegetable oils allows high performance in machining combined with good environment compatibility could be achieved. Compared to mineral oil, vegetable oil can even enhance the cutting performance, extend tool life and improve the surface finish. Although, they have many environmental benefits, vegetable oils are more susceptible to degradation by oxidation or hydrolytic reactions.

A vegetable oil is a triglyceride extracted from a plant. Vegetables oils are classified in two types. They are edible and non-edible oils. Vegetables oils which are used for cooking purposes are called edible oils such as coconut oil, palm oil, palm kernel oil etc., are called as non-edible oils. Non-edible vegetable oils are technically and environmentally acceptable and easily available resource for bio-lubricants. The non-edible oils have large scope to utilize them as metal working fluids. This makes to select non-edible oils such as Neem and Karanja as cutting fluids.

3.1.1 Neem oil:

Neem oil is a vegetable oil pressed from the fruits and seeds of the Neem (Azadirachtaindica), an evergreen tree which is endemic to the Indian subcontinent and has been introduced to many other areas in the tropics. It is the most important of the commercially available products of Neem for organic farming and medicines.

The sources of lubricant used in this study are Neem oil. Neem oil is a vegetable oil pressed from the fruits and seeds of the neem, an evergreen tree which is easily available in India. Neem oil is either reddish brown or greenish brown.

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3.1.2Sunflower oil:- Lubricants are widely used in our industrialized world for reducing friction and wear of machines. A good quality lubricant can contribute substantially towards a more energy efficient engine and increases the engine's lifetime. Technological advances and the making of highly complex and sophisticated engines demand lubricants with increased performance. Mineral oils meet these demands their only drawback being the excessive environmental pollution their disposal after use causes. Biodegradable natural lubricants produced from sunflower oils can, as the current research shows, substitute mineral lubricants offering same quality of engine operation without posing any environmental threat.

3.1.2 Cutting Fluid

Turning experiments was conducted under dry, flood and MQL Conditions. Environment friendly and biodegradable vegetable based Sunflower oil used as cutting oil for MQL i.e. minimum quantity lubrication with sunflower oil (MQLSF). In flood condition of turning, water soluble mineral oil 'Mobilmet 420 series' (Mobil Company) was used which form stable milky white emulsion. It is used with concentration of 1:10 with water..

3.1.3 Flash Point and Fire Point:-

The flash point is the lowest temperature at which vapors of a fluid ignite. Flash point is used to characterize the fire hazards of liquids. Every liquid has a vapor pressure, which is a function of that liquid's temperature. As the temperature increases, the vapor pressure increases. As the vapor pressure increases, the concentration of vapor in the air increases. A certain concentration of vapor in the air is necessary to sustain combustion, and that concentration is different for each liquid. At flash point, a substance will ignite briefly; vapor might not be produced at a rate to sustain the fire.

3.2.2 Viscosity:-

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress or it refers to resistance to flow. A good cutting fluid should have optimum viscosity i.e. if it is high then oils does not carry away heat and chip from machining zone and it will stick the chip in the machining area effecting machining efficiency.

3.2.3 Specific Heat:-

The specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius. A good cutting fluid should have high specific heat, so that it can absorb max heat from the machining zone to rise its temperature instead of allowing heat to transfer the heat to tool and work piece.

3.3 Minimum Quantity Lubrication Equipment

The device for application of MQL having a air compressor and a MQL unit which consists of a small tank (app. ½ lit), flow control valve and a nozzle having 1.5 mm diameter. Fig. 3.2 illustrates the MQL set-up.

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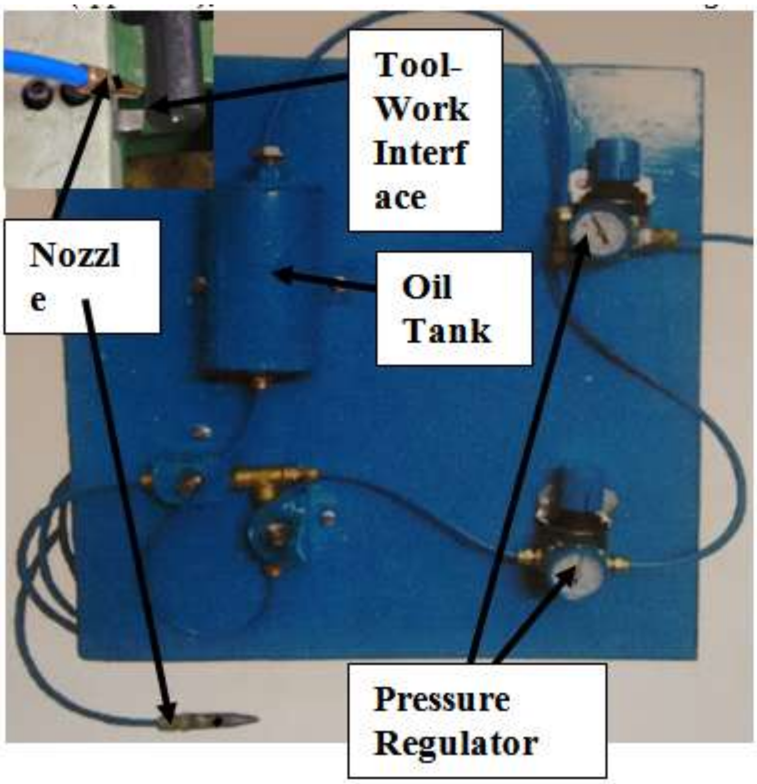

Fig. 3.2 MQL set-up

3.4 Lathe Machine Tool

The conventional lathe machine is used for performing the experimental work. The experiments are performed on a powerful and self centring rigid at different cutting speeds and feeds. Fig. 3.3 shows the general purpose lathe machine used for turning experiments.

Fig. 3.3 Lathe machine

3.5 Mesurement Of Cutting Forces

The measurement of cutting forces is carried out using lathe tool dynamometer. It is a strain-gauge type three components lathe tool dynamometer which is used to measure cutting force, thrust force and feed force generated during the turning operation. Fig. 3.4 shows the lathe tool dynamometer.

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Fig. 3.4 Lathe tool dynamometer

3.6 Measurement Of Machining Temperature

An infrared thermometer (non-contact type) is used for the measurement of the tool-work-chip interface temperature, which is having the range of temperature measure from -100 to 600°C. A laser light is used to point at the tool-work interface for measuring the temperature. The results are obtained by average of 5 readings at different points along the tool-work interface during turning.


Fig 3.5 Infrared Thermometer

3.7 Measurement Of Surface Roughness

If the surface becomes too rough, the cutting tool has to be changed. So it is needed to measure the surface roughness. The surface roughness was measured by profilometer Talysurf (Mitutoyo SJ-201) [Fig. 3.6]. At the end of each test, the average of the surface roughness values, Ra (arithmetic value of surface roughness) of machined surface, were measured at four different points approximately.

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Fig 3.6 Surface Roughness Tester Mitutoyo SJ-201

IV. RESULTS AND DISCUSSION

Physical Properties of Cutting fluids:

4.1 Flash Point and Fire Point:

At the flash point, a substance will briefly ignite; The steam may not be produced at a sufficient speed to sustain the fire. Table 4.1 shows the measured flash point and fire point of different cutting fluids used in the present study. The flash point of the 50% neem and 50% sunflower oil mixture is 251 ° C, which is very high compared to other cutting fluids. Therefore, the mixture of 50% neem and 50% sunflower oil is better to resist the flame.

The fire point is the temperature at which the vapor produced by that particular fluid will continue to burn for at least 5 seconds after ignition by an open flame. The higher the fire point, the higher the resistance to ignition. Therefore, a good cutting fluid must have a higher fire point so that it does not catch fire at machining temperature. The mixture of 50% Neem and 50% sunflower oil has a flash point above 288 ° C and is good at resisting flames, followed by the Neem mixture and with 281 ° C. The flash points and the fire are calculated using the Cleveland apparatus.

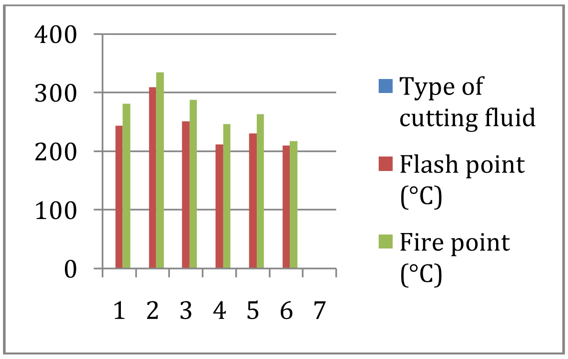


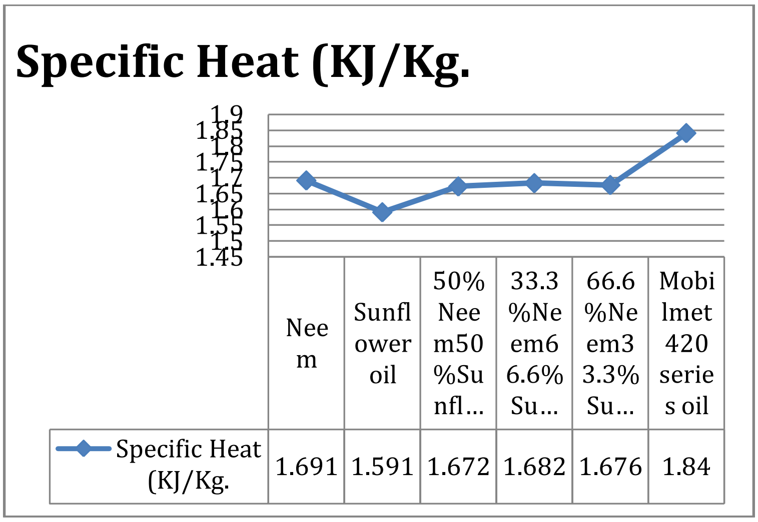
Figure 4.1Flash Points and Fire points of different cutting fluids

4.2 Viscosity

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress or refers to resistance to flow. A good cutting fluid should have an optimal viscosity, that is, if it is high, the oils do not remove heat and chips from the machining area and will stick the chips in the machining area, affecting machining efficiency. If it is low, it will simply move away from the machining zone without lubricating the tool and workpiece. The viscosity of the selected oils is measured using a saybolt viscometer and the values obtained are tabulated in table 4.2 Since the viscosity related to the movement of the oils is important, the dynamic viscosity plays an important role, from the following table you can see that Neem oil has the highest value of 0.0452 Ns / m², the minimum is 0.01243 Ns / m² for 66.6% Neem 33.3% Sunflower oil and the optimum is 50% Neem 50% Sunflower oil with 0.0218 Ns / m². This indicates that the 50% Neem 50% Sunflower Oil blend has both cooling and lubricating properties.

4.3 Specific Heat

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress or refers to resistance to flow. A good cutting fluid should have an optimal viscosity, that is, if it is high, the oils do not remove heat and chips from the machining area and will stick the chips in the machining area, affecting machining efficiency. If it is low, it will simply move away from the machining zone without lubricating the tool and workpiece. The viscosity of the selected oils is measured using a saybolt viscometer and the values obtained are tabulated in table 4.2 Since the viscosity related to the movement of the oils is important, the dynamic viscosity plays an important role, from the following table you can see that Neem oil has the highest value of 0.0452 Ns / m², the minimum is 0.01243 Ns / m² for 66.6% Neem 33.3% Sunflower oil and the optimum is 50% Neem 50% Sunflower oil with 0.0218 Ns / m². This indicates that the 50% Neem 50% Sunflower Oil blend has both cooling and lubricating properties.



4.5 Surface roughness of machined surface:

Surface finish of machined part depends on temperature at machining zone, if the temperature is high the work surface will become brittle and the force required to cut the metal will be high leading very rough surface. Table 4.6 shows Surface roughness measured with cutting fluid and at dry cutting condition. In dry cutting condition, the chips were discontinuous due to the friction in the tool and work interface. As the heat generated is high, the surface near the drill bit becomes brittle and due high cutting force, machined is very rough with highest value of 4.157 µm .During the use of non-edible oil we found that longer chips can be achieved due to the reduction. For Neem and blend of 50% Neem and 50% Sunflower oil, the surface roughness measured 1.279 µm and1.16 µm which is very less compared to other oils. This is due very low temperature at the machining zone and work surface will be ductile in nature leading to lesser cutting force and smooth removal of metal. In case of MOBILMET 420 SERIES OILoil as cutting fluid the surface roughness measured is 3.5 µm, which is due to high friction between the drill bit and work piece.

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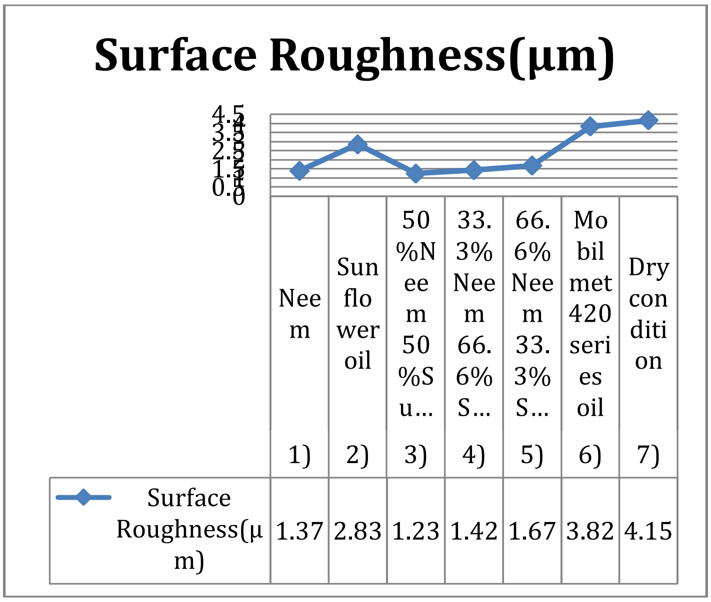
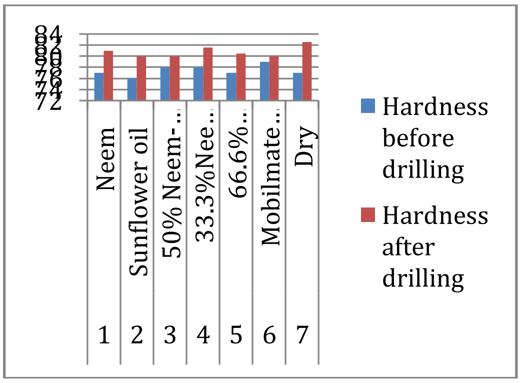


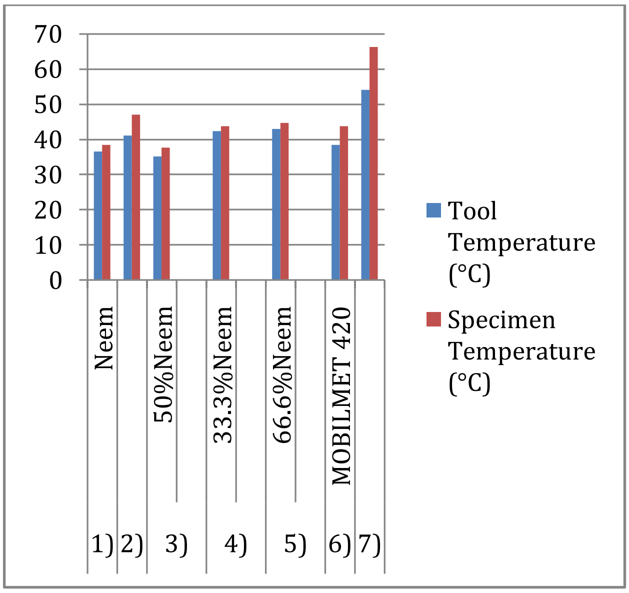
Hardness Test:

Hardness refers to the resistance of a material to indentations and scratching. This is generally determined by forcing an indenter on to the surface. The resultant deformation in steel is both elastic and plastic. The hardness values of all the specimens before machining and after machining operation using different cutting fluids are determined using Rockwell hardness.



4.6 Temperature of work piece and tool during machining:

A good cutting fluid should absorb maximum heat from the machining zone, giving very less heat to tool and the work piece, if not tool life will be less and the machining accuracy will be also be affected along with varying the properties of work piece .Table 4.7 shows, Temperature measured for tool and work piece with cutting fluid and at dry cutting condition. For dry condition temperature of tool and work piece is 54°C and 66.2°C which is very high. This is due to transfer of whatever heat generated to tool and work piece as no coolant is used and also due to high friction between tool and work piece as no lubricant is used. For MOBILMET 420 oil the temperature measured for both tool and the work piece is 38.4 °C and 43.7°C, which is less compared dry cutting but higher than non-edible oils used, this due to its lower adhesiveness and lower dynamic viscosity. For 50%Neem, 50%Sunflower oil blend the temperature of tool and work piece is 35.2°C and 37.7°C very less value compared to other conditions. This is due high specific heat, high adhesiveness and higher dynamic viscosity. Indicating that, this blend has better cooling and good lubricating property.



V. CONCLUSION

a) **Flash point:** The highest flash point of 256˚C was recorded for the blend of 50% Neem- 50% Sunflower oil.

b) **Fire point:** The blend of 50% Neem- 50% Sunflower oil has got highest fire point of 290˚C.

c) **Dynamic Viscosity:** Optimum viscosity of 0.01648 N-s/m² was obtained for the blend of 50% Neem- 50% Sunflower oil.

d) **Specific heat:** Comparing with Specific heats of other cutting fluids the blend of 50% Neem- 50% Sunflower oil has got high specific heat of 1.6862KJ/Kg. K.

e) **Adhesiveness:** The Adhesiveness of the fluid should be optimum, i.e. it should not be high as the fluid helps the chips in sticking to machined surface through and if it low fluid flow through the machining zone and will affect the lubricating property. For 50% Neem- 50% Sunflower oil, the value is 359 g/m2. This value is optimum compared to others used.

II. **Experimental results during machining with various cutting fluids**:

a) **Cutting force: -**The cutting force should be less when a good cutting fluid is used. The cutting force of 169.23N was less for the blend of 50% Neem- 50% Sunflower oil.

b) **Tool and specimen Temperature:-** The temperature of tool and specimen was very less when the blend of 50% Neem- 50% Sunflower oil was used. The temperature of tool was 36.2˚C and the temperature of specimen was 39.1˚C.

c) **Hardness:-** Due to friction the heat flows through the specimen and this heat should be less if the cutting fluid is effective i.e. cutting fluid should absorb more heat. Properties of the specimen will vary compared to parent work piece and this change in properties depends on the heat given to the specimen during machining. For 50% Neem- 50%

d) **Surface Roughness :-** measured on machined surface for different cutting fluids minimum for 50% neem and 50% sunflower oil 1.231 µm.

VI. FUTURE SCOPE

In the present work, it is concluded that the mixture of 50% Neem and 50% sunflower oil is the best cutting fluid for metal cutting work, but the only drawback is that the specific heat is lower compared to other cutting fluids. This can be overcome by adding some additives, which can be taken as future work.

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