Physical Properties of Bio-oils used as cutting fluids during drilling operation of Mild steel

Jyothi PN[*], *Susmitha Medarametla*[**], *Bharath Kumar Mopathi*[***]

Abstract

Cutting fluids are used during machining process to reduce heat and friction on both tool and work piece. The cutting fluids produce three positive effects in the process i.e. heat removal, lubrication on the chip-tool interface and chip removal. Normally used petroleum based cutting fluids damage soil and water resources, causing serious environmental impacts even machine operators are 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. As vegetable oils are not toxic to the environment, biodegradable if spilled and have high flash and fire points. The present paper discusses the measurement of physical properties of Neem, Karanjaand blend of these two oils (50%Neem-50%Karanja, 33.3% Neem 66.6% Karanja, 66.6% Neem-33.3% Karanja) and results are compared with petroleum based SAE 20W40.

Keywords: Neem oil, Karanja oil, drilling, Mild steel, Flashand fire points, Viscosity, Specific Heat, Adhesiveness.

Introduction

Mineral oils were being used as cutting fluids from late 19th century. But these mineral oils both fresh and used can cause considerable damage to the environment. Further the additives contained in those mineral based cutting fluids can be toxic to flora and fauna. The depletion of world oils reserves, increased oils prices and the demand to protect the environment against pollution gave interest in the development of alternative lubricants. Vegetables oils were chosen as the best alternatives to mineral oils because of their effectiveness towards biodegradability. Vegetable oil is a triglyceride extracted from a plant. Vegetable oils are solid at room temperature and sometimes called vegetable fats. Vegetable oils are increasingly being used in many industries as vegetable oils are not toxic to environment and biodegradable. Vegetable oils are basically divided in to edible and non-edible oils. Edible oils are the oils which we consume on a daily basis. But non edible oils are used for external purposes and not used for consumption. Edible oils are restricted to use for industrial purposes due to increased demands catering the growing population.

[*]Professor, Dept. of Mechanical Engineering, K.S. School of Engineering & Management, Bangalore-109, India.
[**]Student, Dept. of Mechanical Engineering, K. S. School of Engineering & Management, Bangalore-109, India.
[***] Post Graduate, Dept.of Mechanical Engineering, Deakin university, Melbourne, Australia.
Correspondence to: Ms. Susmitha Medarametla, Dept. of Mechanical Engineering, K. S. School of Engineering & Management, Bangalore-109, India. ***E-mail Id***: medarametlasusmitha@gmail.com

A good cutting fluid should function safely and effectively during machining operation and also should provide good machining environment. Cutting fluids must offer some degree of corrosion protection, stability or rancidity control, transparency and viscosity, less toxic, should avoid problems associated with heat damage, the production of smoke and fluid ignition. So cutting fluids should be selected based on their flash point, fire point, viscosity, specific heat and adhesiveness.

Experimental Details

Choosing a right metalworking fluid depends on many factors. The benefits of a fluid's versatility should be weighed against its performance in each metalworking application.

The important parameters to be considered while selecting good cutting fluids are:

Type of Machining Process

In this work drilling is the machining operation. In case of drilling, drill bit used for machining is multi point cutting tool and during machining the contact area between tool and work piece is more, so heat generated due to friction is comparatively high.Chips cannot move out easily from the area of machining (hole drilled). Chip disposal is not easy.Heat dissipation is not as fast like turning as process closed.so the cutting fluid used for this operation must resist the heat and must carry away the chips efficiently giving good surface finish.

Type of Work Piece Material

The other factor to be considered while selecting a cutting fluid is the work piece material. The workpiece material used in this work is 1014 mild steel which is 75mm length and 25mm dia. This is because mild steel is used widely in industries.

Type of Cutting Tool Material

The third influential parameter for selection of cutting fluid in machining processes in the cutting tool material. In this work drill bit which is made up of HSS with 10% cobalt which is of 25mm dia. HSS cutting tools can be used with all types of cutting fluids.

The vegetable based cutting fluids used in this work are Neem, Karanja oil and blends of Neem and Karanja oils in proportions of 50% Neem-50% Karanja, 33.3% Neem-66.6% Karanja, 66.6% Neem-33.3.% Karanja and for comparison SAE 20W40.

Neem Oil (Azadirachtaindica)

Neem oil is a vegetable oil pressed from the fruits and seeds of neem, an evergreen tree which is endemic to the Indian sub-continent and has been introduced to many other areas in the tropics.Table1 gives the composition of Neem.

Table 1.Composition of Neem

Average composition of Neem oil fatty acids		
Common Name	**Acid Name**	**Composition range**
Omega-6	Linoleic acid	6-16%
Omega-9	Oleic acid	25-54%
Palmitic acid	Hexadecanoic acid	16-33%
Stearic acid	Octadecanoic acid	9-24%
Omega-3	Alpha-linolenic acid	?%
Palmitoleic acid	9-Hexadecenoic acid	?%

Karanja Oil (Pongamia Oil)

Pongamia oil is derived from seeds of the milletia pinnata tree, which is native to tropical and temperate Asia like India. Table2 gives the composition of Karanja Oil.

Table2.Compostion of Karanja Oil

Fatty Acid	Nomenclature	percentage
Palmitric	C16:0	3.7%-7.9%
Stearic	C18:0	2.4%-8.9%
Oleic	C18:1	44.5%-71.3%
Linoleic	C18:2	10.8%-18.3%
Linolenic	C18:3	2.6%
Arachidic	C20:0	2.2%-4.7%
Eicosenoic	C20:1	9.5%-12.4%
Behenic	C22:0	4.2%-5.3%
Lignoceric	C24:0	1.1%-3.5%

The physical properties to be considered while selecting cutting fluids are:

Flash point and Fire point

A good cutting fluid should possess high flash and fire point so that it can resist the fire at cutting temperatures. The apparatus used to determine the flash and fire points of the cutting fluids is Cleveland's apparatus which is shown in Fig1.

Fig 1.Cleveland's Apparatus

Viscosity

Viscosity is a property of the fluid which opposes the relative motion between the two surfaces. Viscosity of the cutting fluid should be optimum 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 affecting machining efficiency. If it is low then it will just pass away from machining zone without lubricating the tool and work piece. Viscosity of selected oils is measured by using saybolt viscometer which is shown in Fig 2.

 ISSN: 2454-8650

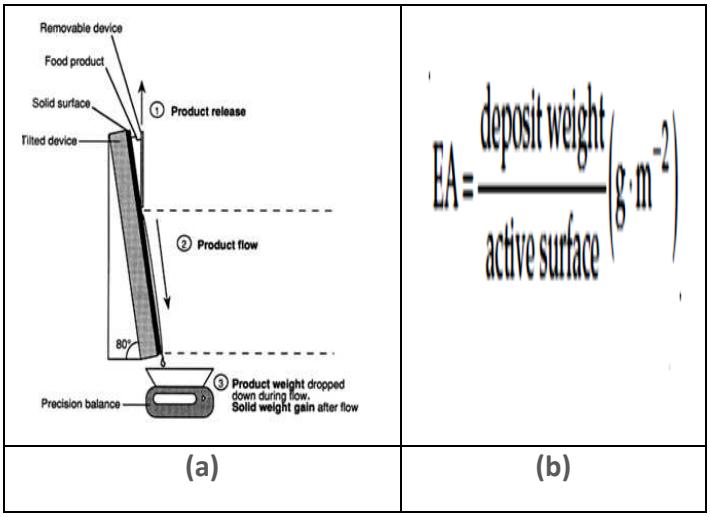
Fig 2.Saybolt Viscometer

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 to tool and work piece.

Adhesiveness

Adhesiveness is the property of cutting fluid referring to ability of fluid to stick to the surface of work and tool during machining and maintain a later separating both elements, so that friction is less.



(Reference: Marie-Caroline Michalski et.al, Adhesion of Edible oils to food contact surfaces, Jaocs, Vol.75, no.4 (1998))

Fig 3.(a) Method used (b) equation used to measure the Adhesiveness of cutting fluid

The drilling operation is carried out on a CNC drilling machine at 800 rpm at constant feed 10 mm/rev using Karanja, Neem, blends of Neem and Karanja with different percentages, petroleum based oils as cutting fluids and also in dry condition. The method of MQL (Minimum quantity lubrication) is used for supplying the cutting fluid.

Results and Discussion

Flash 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. Fig4, shows the measured flash and fire point of different cutting fluids used in the present study. The flash point of blend of 50%Neem and 50%Karanja is 256^{0}C, which is very high compared to other cutting fluids. Hence blend of 50%Neem and 50%Karanja is best in resisting the flame.

The fire point is the temperature at which the vapor produced by that given fluid will continue to burn for at least 5 seconds after ignition by an open flame. Higher the fire point greater will be the resistance to ignite. Hence good cutting fluid should have higher fire point, so that it should not catch fire at drilling temperature. The blend of 50%Neem and 50%Karanja has highest fire point of 290°C is good at resisting the flame, followed by blend of Neem and with 285°c.

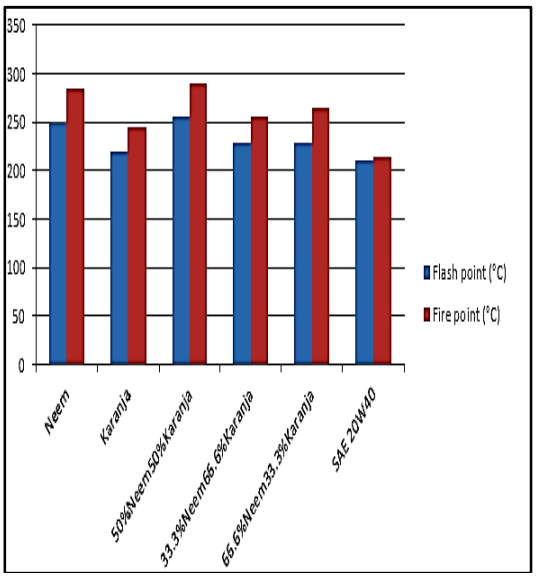


Fig 4.Graph showing Flash and Fire points of different cutting fluids

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. If it is low then it will just pass away from machining zone without lubricating the tool and work piece. Viscosity of selected oils is measured by using saybolt viscometer and values obtained are tabulated in table 3.Since viscosity related to motion of oils is important, dynamic viscosity plays an important role, from theFig5 below is it seen that Neem oil has highest value of 0.0345 N-s/m², least is 0.011271 N-s/m² for 66.6%Neem 33.3%Karanja and optimum is for 50%Neem 50%Karanja with 0.01648 N-s/m². This indicates that the blend of 50%Neem 50%Karanja has both cooling and lubricating property.

 ISSN: 2454-8650

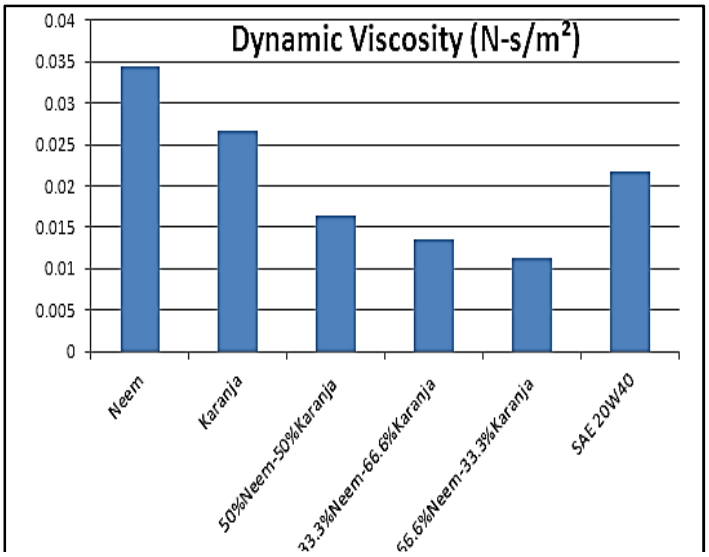


Fig 5.Graph showing Dynamic Viscosity of different cutting fluids

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. Fig6 gives measured values of Specific Heat for different cutting fluids used. From the table it can be seen that blend of 50%Neem 50%Karanja has highest value of 1.6991 KJ/Kg. K followed by pure Neem with value of 1.6817 KJ/Kg. K. This shows blend is capable of absorbing higher heat from the machining zone or acts as good coolant compared to others oils used.

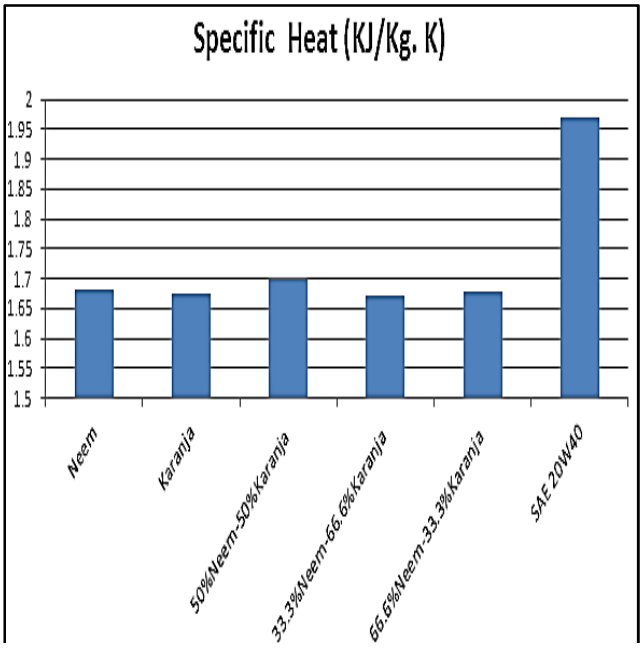


Fig 6.Graph Showing Specific Heat of different cutting fluids

Adhesiveness

This property of cutting fluid refers to ability of fluid to stick to the surface of work and tool during machining and maintain a later separating both elements, so that friction is less. Adhesiveness should not be too high as the fluid will stick to surface along with chips formed. This reduces the life of the tool and machining efficiency. If it is too low then the

fluid cannot separate the elements during machining resulting in higher friction and reduction to tool life. A good cutting fluid should have optimum or moderate value of Adhesiveness, so that both the above problems can be overcome. Table 5 gives the Adhesiveness measured for different cutting fluids. Neem has highest Adhesiveness with value of 687 g/m^2, least is 257 g/m^2 for blend of 33.3%Neem 66.6%Karanja and the optimum is for blend of 50%Neem 50%Karanja with the value of 359 g/m^2. This shows that 50%Neem 50%Karanja is best blend as it separates the machining elements and carries away the heat.

Table 5.Adhesiveness of different cutting fluids

Sl. No	Type of cutting fluid	Adhesiveness(g/m^2)
1)	Neem	687
2)	Karanja	412
3)	50%Neem50%Karanja	359
4)	33.3%Neem66.6%Karanja	257
5)	66.6%Neem33.3%Karanja	367
6)	SAE 20W40	319

References

[1]. B. Satheesh Kumar1, G. Padmanabhan, P. Vamsi Krishna, "Experimental Investigations of Vegetable Oil Based Cutting Fluids with Extreme Pressure Additive in Machining of AISI 1040 Steel", Manufacturing science and Technology 3(1), 1-9, 2015.

[2]. Neetupadhyay, "Environmentally Friendly Machining: Vegetable Based Cutting Fluid" S-JPSET: Vol. 7, Issue 2, ISSN: 2229-7111.

[3]. Sharafadeen K. Kolawole, JamiuK.Odusote, "Performance Evaluation of Vegetable Oil-based Cutting Fluids in Mild Steel Machining", Chemistry and material research,Vol.3.no.9,2013.

[4]. M. M. A. Khan, M.A.H. Mithu, N.R. Dhar "Effects of minimum quantity lubrication on turning AISI 9310 alloy steel using vegetable oilbased cutting fluid", Journal of Materials Processing Technology 209 (2009) 5573–5583, May 2009, page 5573- 5583

[5]. Jitendra Kumar Chandrakar and Amit Suhane, The Prospects of Vegetable Based Oil as Metal working Fluid in Manufacturing Application-A Review, International Journal of Engineering Research and Technology, Vol. 3-Issue 5 (May-2014) ISSN 2278-0181.

[6]. VaibhavKoushik A.V, Narendra Shetty. S & Ram prasad.C, International Journal on Theoretical and Applied Research in Mechanical Engineering (IJTARME) ISSN (Print): 2319-3182, Volume-1, Issue-1, 2012

[7]. M.A. Fairuz, NurulAdlina M.J, A.I. Azmi, M.R.M. Hafieza ,K.W Leong, "Investigation of Chip Formation And Tool Wear in Drilling Process Using Various Types of Vegetable-Oil Based Lubricants", Applied Mechanics and Materials Vols. 799-800 (2015) pp 247-250

[8]. EmelKuram, M. Huseyin Cetin, Babur Ozcelik ,ErhanDemirbas, Performance Analysis of Developed Vegetable-Based Cutting Fluids by D-Optimal Experimental Design in Turning Process, International Journal of Computer Integrated Manufacturing, Volume 25, Issue 12, 2012.

[9]. J. Braz. Soc. Mech.,Journal of the Brazilian Society of Mechanical Sciences, Print version ISSN 0100-7386Sci. vol.23 no.2 Rio de Janeiro 2001.