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Experimental Studies on Turning of AISI 316L Using Modified Neem oil as Straight Cutting oil

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Abstract - In this paper, experiments are conducted on turning AISI 316L material using minimum quantity lubrication technique under formulated Neem oil as cutting fluid. Cutting force, surface roughness and chip formation are studied for the evaluation. The results under the Neem oil are compared with the results turned under conventional mineral oil. The experimental results show that the cutting forces are dropped by 40% under modified Neem oil compared to mineral oil. About 41% drop in surface roughness values are noticed under Neem oil. Further, helical and continuous form chips are seen under vegetable oil mode of lubrication compared ribbon form under mineral oil based cutting fluid.

Index Terms— Minimum Quantity Lubrication, Neem Oil, Machining, AISI 316L, Cutting Forces, Surface Roughness

1 Introduction

Cutting fluid in machining has a vital role in improving the quality and productivity of machining operation. However, the negative effects of conventional cutting fluids on manufacturing cost, human health, and environment have raised alarming signal to the machining industries. These issues have motivated many researchers to look for alternative cutting fluid and techniques in replacing the excessive use of petroleum based cutting fluids. In order to avoid or minimize the use of conventional cutting fluids, alternative fluids based on vegatble oils have been explored.

Vegetable oils consist of primarily of triglycerides, which are glycerol molecules with three long chain fatty acids attached at the hydroxyl groups via ester linkages [1]. The fatty acids found in natural vegetable oils differ in chain length and number of double bonds [2]. The fatty acid composition is determined by the ratio and position of carbon-carbon double bonds. The long carbon chain is generally held together with one, two, or three double bonds: oleic, linoleic, and linolenic fatty acid components respectively [3]. Most of the plant based oils contain at least four and sometimes as many as 12 different fatty acids.

It is reported that triglyceride structure provides desirable qualities for boundary lubrication. It is due to their long and polar fatty acid chains, which provide high strength lubricant films that interact strongly with metallic surfaces, reducing both friction and wear [4]. The polarity of fatty acids produces oriented molecular films, which provides oiliness and imparts antiwear properties. Fatty acids are thus believed to be key substances with regard to lubricity [5, 6].

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2 MATERIALS AND METHODS

2.1 Materials

Methanol and NaoH, Titanium/Sodium methoxide catalyst used for the esterification process are procured from M/s. AB Chemicals, Tumakuru. AISI 316L (work piece) is purchased from M/s Bhansali metal corporation, Bengaluru and HSS M1 C T Tool ISO 6R - 1616 – P30 are purchased from M/s. S Saify & Co. Bengaluru. MQL (Minimum Quantity Lubrication) setup is purchased from M/s. Gautam Rahul Sales, Bengaluru.

2.2 Neem oil

Raw Neem oil is purchased from University of Agricultural Sciences, Bengaluru.

2.3 Preparation of cutting fluid

In the first phase, the Neem oil is esterified into their ester form as Neem oil methyl ester (NOME) and in the second phase, this ester is again esterified with Tri-methyl-propane (TMP) and Neem Tri-methyl-propane ester (NTMPE) is obtained.

2.4 Tests conducted

Physico-chemical properties of raw and modified Neem oil are are evaluated as per ASTM standards.Chemical composition of AISI 316L tested at Mineral and Metallurgical

Laboratories, Bengaluru for confirmation of AISI 316L chemical compositions. Surface roughness (Ra) values are measured using Taly surf instrument (typically a diamond stylus). Cutting force measurement is done using lathe tool dynamometer. AISI 316L material hardness test (Rockwell hardness number) is carried out under Rockwell hardness tester.Turning experiment are conducted using turner Kirloskar (make) LX 175 lathe machine.

3 RESULTS AND DISCUSSIONS

3.1 Physical Properties of Cutting fluids

3.1.1 Flash Point and Fire Point

Fig. 1 represents the flash and fire points of the raw and modified Neem oils & conventional cutting oil. Higher the points, greater will be the resistance to ignite and less tendency for fire hazard during storage and machining. The raw Neem oil has the flash and fire points of 248°C and 285°C respectively. About 10% drop in the flash and fire points are observed under modified version of the Neem oil compared raw oil. However, about 22% flash and 17% higher fire points are seen compared to convetional minerl oil.

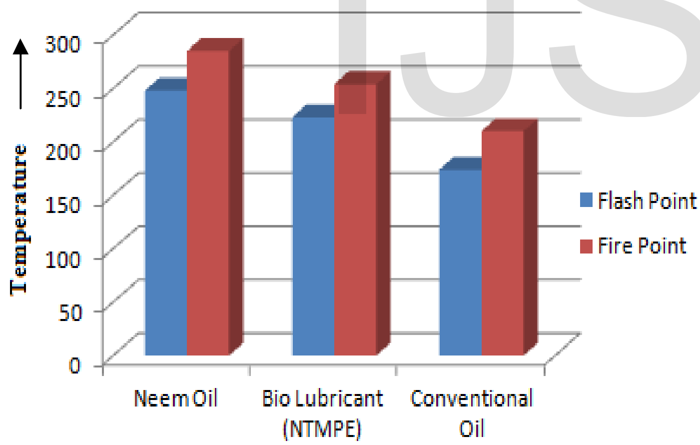

Fig.1. Flash Point and Fire Point of various oils

3.1.2 Viscosity

The property of the fluid which resists the movement of one layer over another adjacent layer of fluid is the viscosity. Viscosity plays a vital role in lubricating the surfaces between tool and workpiece. The viscosity of the raw Neem oil is found to be 0.0345 However, NTMPE viscosity is dropped by 20.28% and 15% compared to raw oil and convetional oil respectively.

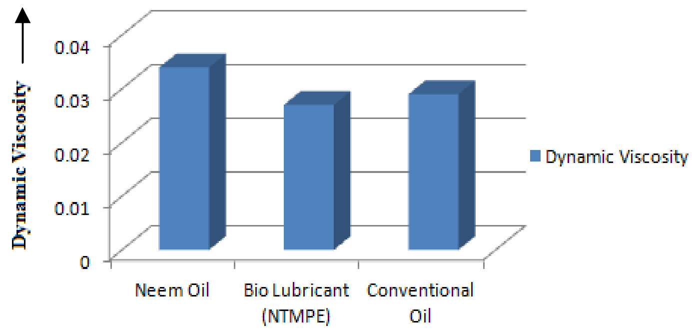

Fig.2 Viscosity of various oils

3.2 Turning Performance

3.2.1 Experimental setup

Work piece is cold rolled AISI 316L bar with a diameter of 55 mm and length of 80 mm. The turning experiments are carried out at cutting speeds of 21, 43 and 68. m/min. Feed rate of 0.21 mm/rev and depth of cut, 0.2 mm is employed during cutting. Tool with clearance angle, 10°, rake angle, 0° and tip radius 0.8 mm is used for machining. Tool holder, PSDN 2525 M12 with inclination angle 45° is used in the set up.Minimum quantity lubrication technique is used to supply the cutting fluid with fluid pressure of 0.3 MPa.

Table 1: Parameters used for turning operation

Parameters	The levels of variation		
	01	02	03
Cutting speed Vc (m/min)	21	43	68
Feed (mm/rev)	0.21mm/rev		
Depth of Cut (mm)	0.2 mm		
Pressure maintained in MQL	0.3 MPa		

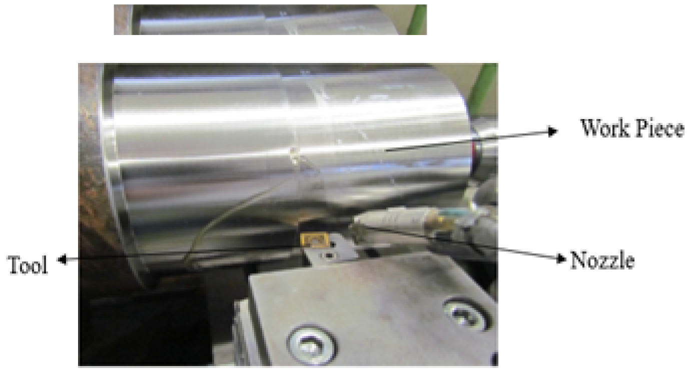

Fig.3.Experimental Machine setup

3.2.2 Cutting forces

In the present work, depth of cut and feed are kept constant, varying the speed for different cutting fluids.Measurement of cutting forces during machining operation indicate the performance of the fluid interms of lubrication between tool and workpiece. A cutting fluid produce low cutting forces during the machining, result in lower mechanical stresses in the work piece [8, 10]. Fig. 4 shows variation of cutting force with speed for various cutting oils. It is observed that the cutting forces are gradually reduced as speed increases. About 23% and 40% drop in the cutting forces under raw Neem oil and NTMPE l respectively compared to conventional oil. Futher, about 52% decrease in cutting forces under NTMPE compared to dry machining.It may be owing to higher oleic fatty acid composition in the Neem oil.

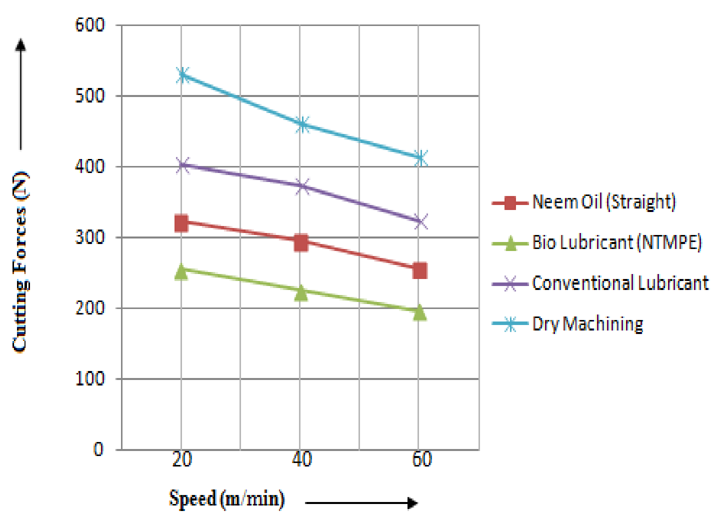

Fig.4. Variation of cutting force with speed for various cutting fluids

3.2.3 Surface Roughness

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 [7, 9]. Fig. 5 represents the variation of surface roughness with speed for various cutting oils. It is observed that the surface roughness would also decreases as cutting speed increases. The surface roufness is comparable both under raw Nemm oil and convetional oil, However, about 41% drop in the surface roughness values under NTMPE conventional oil. Furtehr, about 48.5% drop in surface roughness values compared to dry machining.

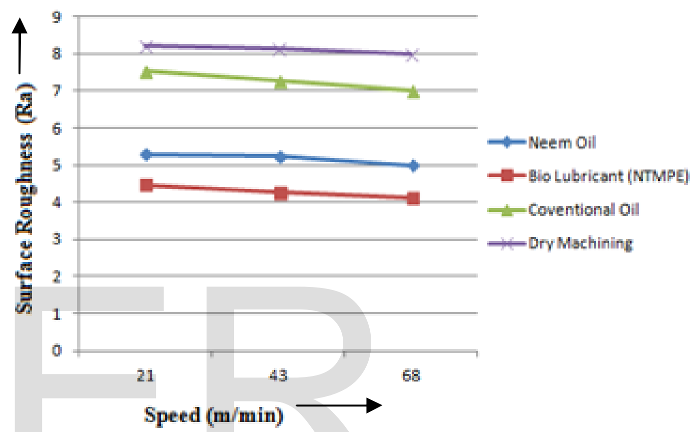

Fig.5. Varation of surface Roughness with speed for various cutting fluids

3.2.4 Chip Forms

During machining, chip formation usually depends on type of metal being machined i.e. weather ductile or brittle and temperature at the machining zone. This temperature is due to friction that exists between tool and the work piece. Chip may break due to chattering of work piece and due to overheating of work surface during the cutting process. Continuous, spiral, ribbon and tubular/helical are obtaining during turning [7].

If the chips formed are uniform and continuous then the cutting fluid used has lubricating properties result in good surface finish. The continuous and uniform chips are found during Bio-Lubricant (NTMPE) used as cutting fluid in machining.

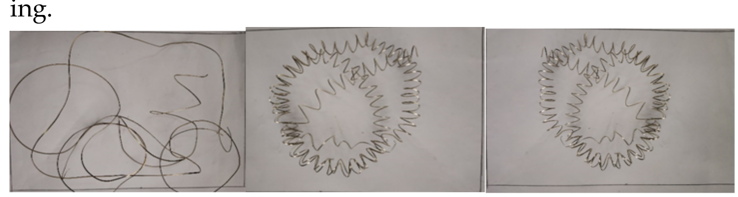

Figure 6: Chips formed under Neem Oil

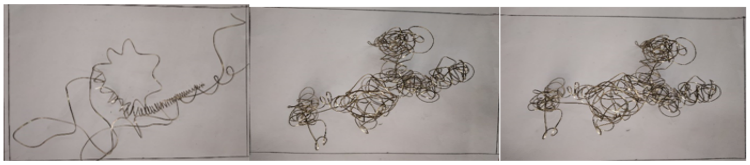

Figure 7: Chips formed under dry Machining

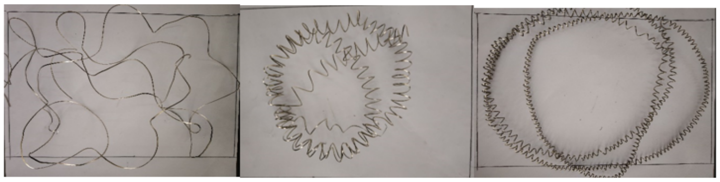

Figure 8: Chips formed under NTMPE

Figure 9: Chips formed under Conventional mineral oil

4 CONCLUSIONS

Both cutting force and Surface rougness values are moderately dropped under the Neem and its modified version of (NTMPE) cutting oil compared to mineral oil. About 40% drop in cutting force and 41% decrease in Surface roughness values are seen under NTMPE. Continuous and uniform chips are found under Neem TMP ester mode of lubrication compared ribbon form under mineral oil based cutting fluid.

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