Analysing the Effect of Coconut Oil Based Cutting Fluid for Turning Operation of EN19 Steel on CNC Lathe

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Abstract— The cutting fluids are responsible for reducing heat at tool work interface, reducing the cut- ting force, easy chip removal, high material removal rate (MRR), lubrication improvement between tool and work piece and thereby increasing the surface finish. Good lubricating capacity, less viscosity, better heat removal rate, high heat conductivity and specific heat are the desired flow and heat transfer parameters of cutting fluids. The development of lubricants like cutting fluids traditionally has mineral oil as base fluid. This fact is related to the technical properties and the reasonable price of mineral oils. Issues of using fluids in machining related to health, environment, and manufacturing cost that need to be solved and options to reduce their use has to be developed. Hence there arises the need for an ecologically benign metal working fluid in machining operations. In this work a coconut oil based cutting fluid is developed with different concentration of oil and water. Different properties of these fluids are also found out. A comparative study of using Coconut oil based fluids and Mineral oil based fluid were conducted by taking EN-19 steel as workpiece material on a CNC lathe.

Key words: Cutting Fluids, CNC Turning Centre, Coconut Oil Based Fluid

I. Introduction

The machining processes have an important place in the traditional production industry. Cutting fluids have been used widespread in all machining processes. The positive effect of the use of fluids in metal cutting was first reported in 1894 by F. Taylor, who noticed that by applying large amounts of water in the cutting area, the cutting speed could be increased up to 33% without reducing tool life. Since then, cutting fluids have been developed resulting in an extensive range of products covering most work-piece materials and operations.

The conventional cutting fluids are the mineral oils in two groups straight oils or water based fluids. The major concerns about the cutting fluids are functional, economic and ecological dimensions. Based on these there are several unsustainable issues. Almost all straight oils are extracted from the crude oil which is decreasing rapidly and in turn increases the price of crude oil and decrease in its availability. The use, disposal etc of conventional cutting fluid will adversely affect the nature very badly. Human health will be negatively affected by direct contact of cutting fluid with skin, which lead to occupational disease and also its contact with eyes will cause damage to the eyes. During machining certain fumes are produced at the contact point, the inhalation of this fume produced causes respiratory diseases. The disposal of this cutting fluid causes air, water and soil pollution. In order to avoid or minimize the use of cutting fluids, several methods were introduced, but make the production costlier. Thus there arise the need of a good alternative cutting fluid which is having the desired properties of the ordinary cutting fluid and which will not produce an environmental impact.In this paper the study of a coconut oil based cutting fluid. A comparative study of Coconut oil based fluids and Mineral oil based fluid were conducted by taking EN-19 steel as workpiece material on a CNC Turning Centre.

II. Literature Review

1) V.D.Prabhu and Praveen D. Dethan (2016) "Experimental Evaluation of Natural Cutting Fluid in Turning" calculated the surface roughness of the mild steel (AISI 1040) work piece in turning under different eco-friendly cutting fluids as a coolant. The single point cutting tool is used for machining cylindrical shape specimen of mild steel. The soya bean oil, coconut oil, canola oil, rice bran and normal coolant (servo-cut oil) are the cutting fluids used in this operation and also the machining process is done in dry condition. A number of tests are performed with different cutting speeds, different cutting fluids and with varying depth of cuts. Surface Roughness values are obtained from these experiments and these are used for data analyzing the cutting process. The High speed steel tool was used for the experimental work. The experiments are carried out to find the variation of Surface Roughness with respect to the cutting speeds and cutting fluids and the best cutting fluid under various cutting speeds and depth was found out.

   It is concluded from the results found out in the previous sections, at 500 rpm coconut oil is having higher surface finish, and also at 325 rpm canola oil is found to be effective. Since eco-friendly fluids are used, the operator had not found any difficulty while doing machining operation and also while disposing the cutting fluids. It is found that eco-friendly cutting fluids are having more surface finish than the conventional cutting fluids .The reusability of cutting fluids has been increased and hence reduction in the cost of cutting fluid. The best surface finish is obtained from the Canola oil with an average surface finish value of 3.031µm at the cutting speed of 325 rpm and 38 mm/min and at 500 rpm coconut oil is found to be effective with average roughness of 3.127µm at 38 mm/min. The surface roughness value of the vegetable oils is less than the normal coolant used. Hence it can be concluded that, the vegetable based coolant derivatives possess good properties and stands next to the coolants derived from petroleum products.
2) K.P.Sodavadia and A.H.Makwana (2014) "Experimental Investigation on the Performance of Coconut oil Based Nano Fluid as Lubricants during Turning of AISI 304 Austenitic Stain- less Steel" presented the performance of nano cutting fluid in machining, one of the most fundamental process in manufacturing industries. The

heat generated at the tool-chip interface during machining is critical for work piece quality. The cutting fluids which are widely used to carry away the heat generated at the tool-workpiece interface in machining process that do not possess a pathogenic clinical history and are relatively free from inherent hazards. Hence there arises a need to develop an eco-friendly and user friendly nano cutting fluid over conventional cutting fluids. Coconut oil has been used as one of the cutting fluids in the work because of its thermal and oxidative stability which is higher than that of other vegetable based cutting fluids used in machining industries. The present work investigates the application of nano Boric acid, solid lubricants suspension in coconut oil during turning of AISI 304 austenitic stainless steel with carbide tool. Where in nano boric acid solid lubricants of 50 nm particle size were suspended in coconut oil, base lubricant. So the variation of average tool flank wear, surface roughness of the machined surface and cutting tool temperature with cutting speed and feed are identify with nano solid lubricant suspensions in coconut oil.

The Nano fluid lubricants were prepared by suspensions of Nano Boric acid in coconut oil so thermal conductivity and heat transfer coefficient increased and specific heat de creased with percentage increase in Nano boric acid. So cutting temperatures, tool flank wear and surface roughness were decreased significantly with Nano lubricants compared to base oil, due to the better lubricating properties of it. In all the cases, coconut oil with 0.5% Nano Boric acid suspensions showed better performance compared to other Nano fluid in terms of cutting temperatures, tool flank wear and surface roughness.

3) Sunday Albert Lawal, Imtiaz Ahmed Choudhury & Yussof Nukman (2013) "Evaluation of vegetable and mineral oil-in-water emulsion cutting fluids in turning AISI 4340 steel with coated carbide tools" The selection of cutting fluid additives for the formulation of oil-in-water emulsion using palm kernel and cottonseed oils are not dangerous or problematic to the environment or harmful to workers. Design of experiment using full factorial method was employed in the process of cutting fluid formulation, while the effect of formulated cutting fluids on surface roughness and cutting force in turning AISI 4340 steel with coated carbide using Taguchi method were investigated and compared with conventional (mineral) oil-in-water emulsion cutting fluid. Four factors and three levels experimental design (L27) was adopted in the Taguchi method. Minitab -14 statistical analysis software which is widely used in engineering application was used in the analysis of S/N (dB) ratio and ANOVA. Cutting speed, feed rate, depth of cut and types of cutting fluids were considered as input parameters. ANO- VA results show that cutting speed (64.64%) and feed rate (32.19%) have significant influence on the surface roughness and depth of cut (33.1%) and type of cutting fluids (51.1%) have significant influence on the cutting force.

The main contribution of this study is that novel vegetable oil in water emulsion cutting fluids formulations have been developed, which could be used to improve the surface roughness and cutting force during turning of AISI 4340 steel with coated carbide tools. The pH values for PKO (10.46) and CSO (10.98) cutting fluids are within the acceptable level required to avoid corrosion during machining process and does not pose any health hazard to worker.

4) Sunday Albert Lawal (2013) "A Review of Application of Vegetable Oil-Based Cutting Fluids in Machining Non-Ferrous Metals" cutting fluids consisted of simple oils applied with brushes to cool and lubricate the machine tool. However, cutting fluid formulation became more complex as cutting operations became more severe. There are several types of cutting fluids nowadays and the most common can be categorised into cutting oils or water-miscible fluids. In this paper, attention is focused on recent research work on the application of vegetable oil-based cutting fluids in machining non-ferrous metals. The efficiency of various vegetable oil-based cutting fluids based on some process parameters such as thrust force, temperature developed at the tool chip interface and flank wear during machining of some non-ferrous metals using different tool materials were highlighted. The results obtained established vegetable oil-based cutting fluids as a good metalworking fluid.

When groundnut, coconut, palm kernel and shear butter oils were used as cutting fluids during the cylindrical turning of copper and aluminium using tungsten carbide tool material. The lowest reduction of cutting forces of 100, 130 and 200N were recorded for groundnut oil when aluminium was machined at cutting speed of 8.25 m/min, depth of cut of 2 mm and feed rates of 0.10, 0.15 and 0.20 mm/rev respectively. While the highest cutting forces of 210, 250 and 380 N were recorded for coconut oil respectively under the same machining conditions. The best cutting force of 220 N was reported for copper when palm kernel oil was used as cut- ting fluid under the same machining conditions.

5) S.A.Lawal, I.A.Choudhury, Y.Nukman (2011) "Application of vegetable oil-based metal working fluids in machining ferrous metals—A review" The increasing attention to the environmental and health impacts of industrial activities by governmental regulations and by the growing awareness level in the society is forcing industrialists to reduce the use of mineral oil- based metalworking fluids as cutting fluid. Cutting fluids have been used extensively in metal cutting operations for the last 200 years. In the beginning, cutting fluids consisted of simple oils applied with brushes to lubricate and cool the machine tool. As cutting operations became more severe, cutting fluid formulations became more complex. There are now several types of cutting fluids in the market and the most common types can be broadly categorised as cutting oils or water-miscible fluids. In this review, the applicability of vegetable oil-based metal- working fluids in machining of ferrous metals has been undertaken. The advantages of metal- working fluids and its performances with respect to the cutting force, surface finish of work piece, tool wear and temperature at the cutting zone have been investigated. It has been report- ed that metal working fluids, which are

vegetable oil-based, could be an environmentally friendly mode of machining with similar performance obtained using mineral oil-based metalworking fluids.

6) Y.M.Shashidhara, S.R.Jayaram (2010) “Vegetable oils as a potential cutting fluid—an evolution” study highlights the contributions from more than sixty authors on vegetable based oils as emerging environmental friendly cutting fluids. The performance of these oils as emulsions and straight oils for various materials and machining conditions are reported. The study focuses on the evolution of vegetable oils as cutting fluids in manufacturing sector, particularly, metal cutting and metal forming. It is observed that, most of the contributions are directed to develop and commercialise the cutting fluids based on vegetable oils.

   Vegetable oils were found to be promising alternative for mineral based oils due to their environmental friendly characteristics. These were utilized to develop biodegradable lubricants for various industrial applications. The trend was extended to formulate environmental friendly metal working fluids. The review is made in two approaches, one based on the desirable properties of vegetable oil as metal working fluid and other on the performance of these oils for various cutting and forming operations. Finally, the review revealed that the vegetable oils have large scope to utilize them as metal working fluids.

7) Patrick Adebisi Olusegun Adegbuyi, Ganiyu Lawal, Oluwatoyin Oluseye, Ganiyu Odunaiya(2010) “Analyzing the effect of cutting fluids on the mechanical properties of mild steel in a turning operation” Cutting fluids are used in machining for a variety of reasons such as improving tool life, reducing work-piece thermal deformation, improving surface finish. In this work soluble oil, water and palm kernel oil were used as coolants in turning operations. Tungsten carbide and HSS cutting tools were employed as cutter with cutting speed of 355rpm. Turning was done under dry condition and also using 3 coolants. Temperature and Hardness values after each cut were recorded. The microstructure of all the specimen was also done and recorded. It was revealed that variation in the Hardness value of the samples with progress in machining time is more with the use of carbide tool compared to the HSS cutter. Samples cooled with water exhibited the highest hardness value.

8) Salete Martins Alves , Joao Fernando Gomes de Oliveira “Development of new cutting fluid for grinding process adjusting mechanical performance and environmental impact” new combinations of fluids and grinding wheels have been tested in research projects. The applica- tion of grinding wheels using cubic boron nitrite (CBN) abrasives is a strong tendency in grinding. An environmentally friendly fluid has to accomplish some main requirements, such as should not be toxic, biodegradable and should produce low emissions when in use. But also an ideal fluid has to provide good process performance and allow low costs in the application of CBN based tools. This work presents a new grinding fluid formulation able to meet both the performance and environmental requirements. The proposed fluid is based on a sulfonate vegetable oil with high concentration in water for grinding with CBN in high speed. This way it is possible to get high lubricity and good performance on CBN grinding. The tests show that the application of the proposed formula in CBN grinding results in process performance equivalent to the obtained using mineral neat oils. The parameters evaluated were radial wheel wear and workpiece roughness. Chemical analysis shows the new fluid as to be non-toxic and have easy biodegradability. The cutting fluid developed in this work has filled all environmental requirements as well as has a good grinding performance.

9) Ajay Vardhaman B. S , M. Amarnath, Durwesh Jhodkar , J. Ramkumar and H. Chelladurai “Examining the Role of Cutting Fluids in Machining AISI 1040 Steel Using Tungsten Carbide Insert under Minimal Quantity Lubrication Condition “ all machining operations, tool wear is a natural phenomenon. Excessive wear on cutting tools alter the dimensions of manufactured components, which result increase in scrap levels thereby incurring additional costs. Though cutting fluids are widely employed to carry away the heat generated at the tool-work piece interface, their applications have several adverse effects on ecology and the health of workers. Attempts have already been initiated to control the pollution problem using minimal quantity lubrication (MQL) method which also leads to economical benefits and work piece/tool/ma- chine cleaning cycle time. In the present work, experimental investigations were carried out to investigate the role of MQL by vegetable oil on cutting forces and tool wear in tuning AISI 1040 steel using tungsten carbide cutting tool insert. The results revealed that, the performance of MQL by coconut oil found to be superior to that of dry turning, conventional wet turning and MQL by soluble oil on the basis of cutting force and tool life.

10) Sanusi Olawale Monsur, Bello Yekini and Akindapo Jacob Olaitan “Evaluating the performance of different type of cutting fluid in the machining of aluminium-manganese alloy in turning operation” The research aimed to evaluate the performance of neem seed oil as a cut- ting fluid in orthogonal machining of aluminium-manganese alloy 3003, carbide cutting tool insert was used as a cutting tool under different machining parameters of spindle speed, feed rate and depth of cut with different types of cutting fluids (neem seed oil and soluble oil) as well as dry machining. The results were obtained in terms of the average surface roughness of the machined workpiece and flank wear under different cutting parameters (spindle speed, feed rate and depth of cut). The results indicated that the neem seed oil cutting fluid reduced the surface roughness by 39% and 22% as compared to dry turning and soluble oil cutting respectively. It was established from the results that the neem seed oil cutting fluid reduced the flank wear by 72% and 56% as compared to dry turning and soluble oil cutting respectively. Based on the study, it can be concluded that neem seed oil cutting fluid facilitates a better surface finish and substantial reduction in tool wear when compared with dry and soluble oil machining.

11) Prasanna P Kulkarni, Shreelakshmi.C.T., Shruti.V.Harihar, Radha Bai.N. "An Experimental Investigation of Effect of Cutting Fluids on Chip Formation and Cycle Time in Turning of EN-24 and EN-31 Material" The chip formation is not only depending upon the work piece material but even on the cutting fluids and grain structure of the materials. Cutting fluids have seen extensive use and have commonly been viewed as a required addition to high productivity and high quality machining operations. This experiment is to determining the effect of cut- ting fluids and cutting parameters on chip formation mode and cycle time in turning of EN-24 and EN-31 material. The above operation has been carried out in dry cutting condition, Flood application of cutting fluids. Cutting fluids like soluble oil and palm oil used in the present work. The cutting operations were carried out on a conventional lathe machine there by making turning operation with uncoated carbide cutting tool at different spindle speed(n) of 210rpm, 450rpm and 750rpm.Also feed(f) of 0.1rev/min to 0.2rev/min. Depth of cut is kept constant at 1.5mm. By using the vegetable oil we can improve the surface finish, metal removal rate and to reduce the environmental effects. After conducting these experiments it was recorded chip morphology and cycle time value for each fluid under different cutting conditions. It was observed light colour chips with segmented form in vegetable based oil at lower cutting conditions for each material.
12) Ujjwal Kumar, Atif Jamal, Aftab A. Ahmed "Performance Evaluation of Neat Vegetable Oils as Cutting Fluid during CNC Turning of Aluminium (AA1050)" Comfortable and healthy workplaces are important for sustainable machining. Sustainable machining should be reliable and consistent. Green machining means environment friendly and hazard free, this is some- how achieved by the machining with Vegetable oil Based Cutting Fluids (VBCFs). Unfortunately, Metal Working Fluids also have several negative health and environmental impacts. Vegetable oils have become identified world over as a potential source of environmentally favourable metal working fluids due to a combination of biodegradability, renewability and excellent lubrication performance. This paper focuses on an experimental investigation into the role of green machining on surface Roughness (Ra), in the machining of aluminium AA1050. A comparative study of turning experiments, between VBCFs and MBCFs under various cutting conditions, using neat or straight Coconut oil and Castor oil, was conducted using the same machining parameter set-up. Vegetable oils used on the principle of Minimum Quantity Lubrication (MQL) that is oil dropped between the cutting tool and workpiece inter- face directly. The results show that vegetable oil performance is comparable to that of mineral oil machining. The results show that Vegetable oils have potential to replace the Mineral oils.

III. Research Gap

Most of the researchers have used neat vegetable oils as cutting fluid but needs to add some additives for make better cutting fluid.

Results shows that some properties which is required for better cutting fluid is almost same in vegetable oil & generally used oil.

Coconut oil has a long shelf life compared to other oils, lasting up to two years due to its resilience to high temperature. Coconut oil is best stored in solid form at tempera- ture lower than 24.5°C (76°F) in order to extend shelf life. However, unlike most oils, coconut oil will not be damaged by warmer temperatures and coco cutting fluid can be a good substitute cutting fluid in turning.

There is very less work in EN19 workpiece material using natural cutting fluid.

IV. Preparation of Cutting Fluid

Coconut oil is used as the base fluid for the preparation of cutting fluid. The formulation act as an oil in water emulsion. Oleic acid is an unsaturated fatty acid which is used as an emulsifying or solubilizing agent. Besides serving as an agent for improving the lubricity of the cutting fluid, it also acts as friction modifier for lowering the friction coefficient. In water soluble cutting fluids, triethanolamine is used to provide the alkalinity needed to protect against rusting and it acts as an anti-oxidant. It also controls the evaporation rate of water in cutting fluid.

Coconut oil based concentrate was formulated by mixing coconut oil with Oleic acid and Triethanolamine in the ratio of 2:2:1 respectively. For preparing 500 ml of oil concentrate 200ml of coconut oil was taken in beaker and 200ml of oleic acid is added slowly. The mixture was stirred thoroughly using a mechanical stirrer up to when a homogenous liquid is formed. Then 100ml of triethanolamine was added to it and stirred well so as to get a homogenous mixture. Thus the oil concentrate is prepared. This homogenous mixture can dissolve in water in all proportions and functions as oil in water emulsion. Four emulsion samples were formed by varying the concentration of oil as 10%, 20%, 30% and 40%, remaining water. For preparing the emulsion the required quantity of water was taken and the water is stirred using a stirrer so that a vortex was formed. Then the oil was slowly poured into the vortex. The stirring was continued for few minute until we get a homogenous emulsion.

A. *Properties of Oil*

Properties	Coconut Oil	Oleic Acid	Triethanol Amine
Boiling Point(ºC)	177	360	335.40
Viscosity(cP)	80	27.64	590.5
pH	7.3	4.5	10.5
Density (at 25ºC)	0.903 g/mL	0.895 g/mL	1.124 g/mL
Solubility	Soluble in water	soluble in water	Soluble in water
Flash Point(ºC)	171	189	179

Properties of coconut oil, oleic acid and Triethanol Amine

B. Comparison of properties of Cutting Fluid

The selection of cutting fluid is based on some basic properties. The basic properties which determine the selection of cutting fluid are viscosity, thermal conductivity, acidity or alkalinity, relative density.

1) *Viscosity:*

Viscosity is a measure of the resistance of a fluid to deform under shear stress. Viscosity is due to the friction between neighbouring particles in a fluid that are moving at different velocities.

Temperature(ºC)	10%	20%	30%	40%	Mineral Oil
32	3.637	7.36	14.22	33.045	3.169
40	2.183	5.547	10.886	23.043	2.553
65	1.003	3.671	9.764	15.66	1.211

Table: Viscosity at different temperature (cP)

The table shows the variation of viscosity with respect to temperature of different cutting fluids. It is seen that the mineral oil based cutting fluid is having the least value of viscosity at three different temperatures. Coconut oil based cutting fluid with 10% and 20% oil concentration is having comparable viscosity with mineral oil based cutting fluid. But other two combination of coconut oil based cutting fluid is having higher viscosity when compared with mineral oil based cutting fluid. The viscosity of cutting fluid increases the lubrication effect but it reduces the flowability of cutting fluid. So a moderate viscosity is desirable for a cutting fluid. The viscosity of all fluids decreases with increase in temperature.

2) *Thermal Conductivity:*

Thermal conduction is a very important and a major topic in the study of heat transfer. Conduction is the transfer of energy from energetic particles of a substance to the adjacent less energetic ones as a result of interactions between the particles.

Oil	10%	20%	30%	40%	Mineral Oil
Thermal Conductivity	0.489	0.471	0.426	0.343	0.404

Table: Thermal Conductivity of fluids (W/mK)

The thermal conductivity of cutting fluids considered are shown in the table among these cutting fluids the coconut oil based cutting fluid with 10% oil concentration gives maximum thermal conductivity. The thermal conductivity of coconut oil based cutting fluid with 40% oil concentration is having least thermal conductivity which is also less than mineral oil based cutting fluid. All other cutting fluids developed from coconut oil showed more thermal conductivity than mineral oil based cutting fluid. So the cooling effect that can be produced by these fluid is more than that of mineral oil based cutting fluid. As the water content in emulsion increases the thermal conductivity of emulsion also increases.

3) *Relative Density:*

Relative density is the ratio of the density of liquid to the density of water at same condition of temperature and pressure. The density of liquid is required to calculate flow rates and for the conversion of kinematic viscosity to dynamic viscosity. A good cutting fluid should always possess good flow ability as well as good lubricating property. For this the relative density should not be so high or so low. Most mineral oils have the viscosity in the range between 0.85 to 0.95.

In order to measure the relative density the weight of 25ml of water is measured using a digital weight meter then the weight of 25ml of required sample is also taken. Then by taking the ratio between weights of fluid to weight of water the relative density of required fluid sample is obtained.

Oil	10%	20%	30%	40%	Mineral Oil
Relative Density	0.998	0.98	0.966	0.921	0.978

Table: Relative Density of fluids

The relative density of different cutting fluid are shown in the table .The relative density of coconut oil based fluid having 10% oil concentration is almost equal to 1. Coconut oil based cutting fluid with 10% and 20% oil concentration is having more relative density than mineral oil based cutting fluid. Other two fluids are having lesser relative density. The increase in oil content decreases the relative density of emulsion.

4) *Acidity and Alkalinity:*

The nature of cutting fluid in case of acidity also determines the selection of cutting fluid. The acidity or alkalinity of cutting fluid can be determined by using a pH meter. The pH scale shows a fluid's acidity or alkalinity. The fluid having a value less than 7 during pH test is acidic in nature and pH value greater than seven is basic in nature. Pure water is having a pH value of seven. In case of cutting fluid the fluid is commonly made basic. The acidity of cutting fluid will produce a chance of combustion during machining. So cutting fluids are commonly basic in nature. Basic nature of the cutting fluid also protects the work piece from corrosion or oxidation and it helps in stabilizing the emulsion.

Oil	10%	20%	30%	40%	Mineral Oil
pH	8.65	8.6	8.49	8.43	7.35

Table: pH of Cutting fluids

V. EXPERIMENTAL DETAILS

SL. No	Factors	Units	Levels		
1	Cutting Speed	m/min	120	150	180
2	Feed	mm/res	0.1	0.15	0.2
3	Depth Of Cut	mm	0.5	1	1.5

Table: Cutting speed, feed and Depth of cut of CNC lathe

Combination of feed, speed and depth of cut selected for the study is shown in table. From the Taguchi Design of experiment total 27 experiment required (L27).Each combination is machined in 6 different condition i.e., machining with mineral oil based cutting fluid, dry machining, machining with coconut oil based cutting fluid having 10%,20%,30% and 40% of oil concentration. So that total 162 experiment required. Turning is carried out for a 20mm length which is just enough surface area to allow for cutting stabilization and subsequent surface roughness measurement. After machining the workpiece is given to the inspection section of surface roughness. The tool workpiece interface temperature measure using infrared thermometer.

Trial No	Depth Of Cut (mm)	Speed (m/min)	Feed (mm/rev)	Type of oil	Roughness Average Ra (µm)	Temperature
1	0.5	120	0.1	Dry	1.675	68
2	0.5	120	0.1	Mineral	0.862	47.6
3	0.5	120	0.1	10%	0.902	43.4
4	0.5	120	0.1	20%	0.856	44
5	0.5	120	0.1	30%	0.864	48.5
6	0.5	120	0.1	40%	0.927	52.6
7	0.5	120	0.15	Dry	1.873	70.2
8	0.5	120	0.15	Mineral	1.035	46.8
9	0.5	120	0.15	10%	1.139	42.4
10	0.5	120	0.15	20%	0.964	43.2
11	0.5	120	0.15	30%	0.974	49.7
12	0.5	120	0.15	40%	0.985	55.4
13	0.5	120	0.2	Dry	2.047	66.7
14	0.5	120	0.2	Mineral	0.986	44.5
15	0.5	120	0.2	10%	1.17	41.9
16	0.5	120	0.2	20%	0.979	42.4
17	0.5	120	0.2	30%	0.996	48.7
18	0.5	120	0.2	40%	1.112	54.2
19	0.5	150	0.1	Dry	1.495	65.8
20	0.5	150	0.1	Mineral	0.941	46.7
21	0.5	150	0.1	10%	0.905	42.8
22	0.5	150	0.1	20%	0.85	43.1
23	0.5	150	0.1	30%	0.856	49.6
24	0.5	150	0.1	40%	0.915	56.3
25	0.5	150	0.15	Dry	1.675	66
26	0.5	150	0.15	Mineral	0.93	43.9
27	0.5	150	0.15	10%	0.981	41.2
28	0.5	150	0.15	20%	0.938	41.4
29	0.5	150	0.15	30%	0.954	47.7
30	0.5	150	0.15	40%	0.977	58.2
31	0.5	150	0.2	Dry	1.914	68
32	0.5	150	0.2	Mineral	0.983	42.2
33	0.5	150	0.2	10%	1.21	40.4
34	0.5	150	0.2	20%	0.969	41.4
35	0.5	150	0.2	30%	0.978	49.6
36	0.5	150	0.2	40%	1.1	57.4
37	0.5	180	0.1	Dry	1.414	67.8
38	0.5	180	0.1	Mineral	0.829	43.5
39	0.5	180	0.1	10%	0.894	42.5
40	0.5	180	0.1	20%	0.839	43
41	0.5	180	0.1	30%	0.844	48.4
42	0.5	180	0.1	40%	0.908	57.4
43	0.5	180	0.15	Dry	1.597	69.5
44	0.5	180	0.15	Mineral	0.962	45.6
45	0.5	180	0.15	10%	1.079	41.2
46	0.5	180	0.15	20%	0.953	42
47	0.5	180	0.15	30%	0.962	49.2
48	0.5	180	0.15	40%	0.984	55.2
49	0.5	180	0.2	Dry	1.958	67.9
50	0.5	180	0.2	Mineral	1.168	44
51	0.5	180	0.2	10%	1.235	41.1
52	0.5	180	0.2	20%	0.981	41.9
53	0.5	180	0.2	30%	0.993	48.9

54	0.5	180	0.2	40%	1.125	56.9
55	1.0	120	0.1	Dry	1.638	77.4
56	1.0	120	0.1	Mineral	0.842	56.8
57	1.0	120	0.1	10%	0.894	52.7
58	1.0	120	0.1	20%	0.836	53.1
59	1.0	120	0.1	30%	0.845	57.3
60	1.0	120	0.1	40%	0.919	61.1
61	1.0	120	0.15	Dry	1.842	80.1
62	1.0	120	0.15	Mineral	1.004	56.2
63	1.0	120	0.15	10%	1.062	52.3
64	1.0	120	0.15	20%	0.946	53.4
65	1.0	120	0.15	30%	0.958	58.9
66	1.0	120	0.15	40%	0.972	65.2
67	1.0	120	0.2	Dry	1.987	76.3
68	1.0	120	0.2	Mineral	0.972	54.4
69	1.0	120	0.2	10%	0.992	51.8
70	1.0	120	0.2	20%	0.947	53.1
71	1.0	120	0.2	30%	0.952	59.8
72	1.0	120	0.2	40%	0.986	65.2
73	1.0	150	0.1	Dry	1.372	75.2
74	1.0	150	0.1	Mineral	0.922	56.6
75	1.0	150	0.1	10%	0.814	52.3
76	1.0	150	0.1	20%	0.791	52.9
77	1.0	150	0.1	30%	0.803	59.4
78	1.0	150	0.1	40%	0.825	66.1
79	1.0	150	0.15	Dry	1.515	76.3
80	1.0	150	0.15	Mineral	0.901	53.7
81	1.0	150	0.15	10%	0.951	51.1
82	1.0	150	0.15	20%	0.926	51.6
83	1.0	150	0.15	30%	0.945	57.3
84	1.0	150	0.15	40%	0.948	68.1
85	1.0	150	0.2	Dry	1.901	78.2
86	1.0	150	0.2	Mineral	0.962	51.9
87	1.0	150	0.2	10%	1.01	50.7
88	1.0	150	0.2	20%	0.942	50.9
89	1.0	150	0.2	30%	0.954	59.4
90	1.0	150	0.2	40%	0.98	67.2
91	1.0	180	0.1	Dry	1.316	80.4
92	1.0	180	0.1	Mineral	0.782	53.1
93	1.0	180	0.1	10%	0.802	52.8
94	1.0	180	0.1	20%	0.771	52.9
95	1.0	180	0.1	30%	0.818	58.1
96	1.0	180	0.1	40%	0.886	66.9
97	1.0	180	0.15	Dry	1.412	79.1
98	1.0	180	0.15	Mineral	0.932	55.2
99	1.0	180	0.15	10%	0.986	50.9
100	1.0	180	0.15	20%	0.904	51
101	1.0	180	0.15	30%	0.911	58.8
102	1.0	180	0.15	40%	0.934	64.9
103	1.0	180	0.2	Dry	1.884	78.1
104	1.0	180	0.2	Mineral	1.108	53.8
105	1.0	180	0.2	10%	1.202	52.1
106	1.0	180	0.2	20%	0.954	52.4
107	1.0	180	0.2	30%	0.961	58.8
108	1.0	180	0.2	40%	0.998	66.7
109	1.5	120	0.1	Dry	1.512	88.1
110	1.5	120	0.1	Mineral	0.821	67.4
111	1.5	120	0.1	10%	0.872	64.1

112	1.5	120	0.1	20%	0.812	65.3
113	1.5	120	0.1	30%	0.823	69.1
114	1.5	120	0.1	40%	0.889	73.2
115	1.5	120	0.15	Dry	1.778	82.4
116	1.5	120	0.15	Mineral	0.998	68,1
117	1.5	120	0.15	10%	1.02	64.2
118	1.5	120	0.15	20%	0.924	65.4
119	1.5	120	0.15	30%	0.93	70.8
120	1.5	120	0.15	40%	0.947	76.3
121	1.5	120	0.2	Dry	1.897	87.1
122	1.5	120	0.2	Mineral	0.934	65.1
123	1.5	120	0.2	10%	0.924	63
124	1.5	120	0.2	20%	0.906	65.3
125	1.5	120	0.2	30%	0.916	71.6
126	1.5	120	0.2	40%	0.948	76.4
127	1.5	150	0.1	Dry	1.304	85.9
128	1.5	150	0.1	Mineral	1.902	67.2
129	1.5	150	0.1	10%	0.802	63.1
130	1.5	150	0.1	20%	0.769	64.2
131	1.5	150	0.1	30%	0.791	70.8
132	1.5	150	0.1	40%	0.804	76.7
133	1.5	150	0.15	Dry	1.402	86.8
134	1.5	150	0.15	Mineral	0.88	64.3
135	1.5	150	0.15	10%	0.931	62.8
136	1.5	150	0.15	20%	0.904	63.1
137	1.5	150	0.15	30%	0.926	68.6
138	1.5	150	0.15	40%	0.934	79.9
139	1.5	150	0.2	Dry	1.708	89.4
140	1.5	150	0.2	Mineral	0.904	63.2
141	1.5	150	0.2	10%	0.943	61.8
142	1.5	150	0.2	20%	0.912	61.9
143	1.5	150	0.2	30%	0.928	70.1
144	1.5	150	0.2	40%	0.94	78.4
145	1.5	180	0.1	Dry	1.208	90.8
146	1.5	180	0.1	Mineral	0.741	64.1
147	1.5	180	0.1	10%	0.782	63.8
148	1.5	180	0.1	20%	0.751	63.9
149	1.5	180	0.1	30%	0.779	69.1
150	1.5	180	0.1	40%	0.802	77.4
151	1.5	180	0.15	Dry	1.261	90.1
152	1.5	180	0.15	Mineral	0.903	66.4
153	1.5	180	0.15	10%	0.951	62.1
154	1.5	180	0.15	20%	0.848	63.3
155	1.5	180	0.15	30%	0.869	64.1
156	1.5	180	0.15	40%	0.908	69.4
157	1.5	180	0.2	Dry	1.664	89.1
158	1.5	180	0.2	Mineral	1.026	65.1
159	1.5	180	0.2	10%	1.104	63.8
160	1.5	180	0.2	20%	0.931	64.2
161	1.5	180	0.2	30%	0.942	69.4
162	1.5	180	0.2	40%	0.981	77.3

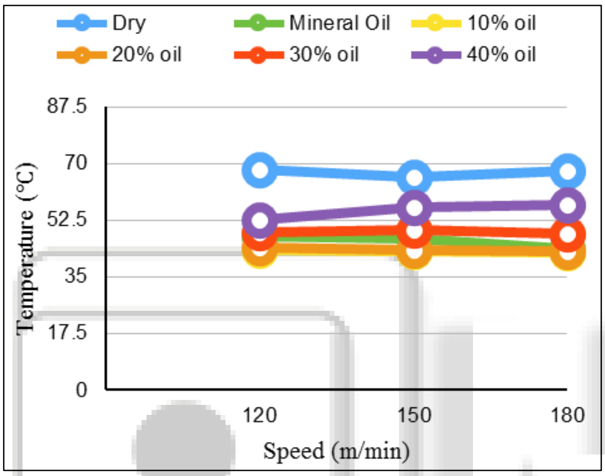
VI. RESULT AND DISCUSSION

The datas analyse and compare input parameter to response parameter.

- Comparison of Ra with respect to speed
- Comparison of Ra with respect to feed
- Comparison of Ra with respect to depth of cut
- Comparison of Temperature with respect to speed
- Comparison of Temperature with respect to feed
- Comparison of Temperature with respect to depth of cut

A. Comparison of Ra with respect to speed

Variation of roughness average with speed for different cutting fluids at 0.5 mm depth of cut and 0.1 mm/rev feed. It is clear that surface roughness produced in dry machining is more than that of other cutting fluids in all combination of parameters. The coconut oil based cutting fluid with 20% and 30% oil concentration showed better result than mineral oil based cutting fluid and other 2 two type of coconut oil based cutting fluid. The coconut oil based cutting fluid with 10% oil concentration produces less lubricating effect since it is having less oil content and also it is having lesser viscosity than mineral oil based cutting fluid. But in case of coconut oil based cutting fluid with 40% oil concentration it is having high value of viscosity so the flowability of fluid is less thus the roughness produced will be high. It is clear that as the speed of cutting increases the Ra is decreasing. High speed is desirable for better surface finish.



B. Comparison of Ra with respect to feed

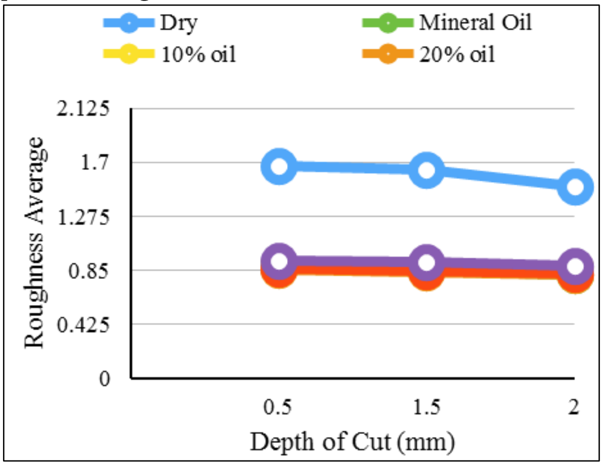
Variation of roughness average with feed for different cutting fluid at 120 m/min speed and 0.5 mm depth of cut, it can be seen that the surface roughness value is more in dry machining condition during all the cutting condition. The coconut oil based cutting fluid with 20% and 30% oil concentration shows minimum surface roughness than other variety of cutting fluid including mineral oil based cutting fluid. The coconut oil based cutting fluid with 10% and 40% oil concentration shows higher value of roughness than mineral oil based cutting fluid.

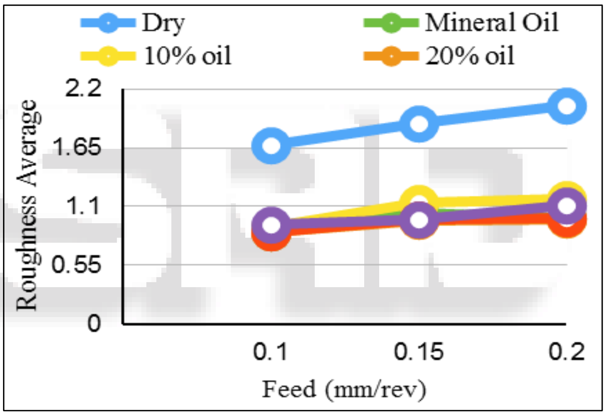
C. Comparison of Ra with respect to Depth of cut

Variation of roughness average with depth of cut at 120 mm/min speed and 0.1 mm feed shown in graph, it is clear that as depth of cut increase; the surface roughness decrease. So that the workpiece which have more depth of cut have low surface roughness. The coconut oil based cutting fluid with 20% with more. Depth of cut have lower roughness than others so that it is required to more depth of cut for low surface roughness.

D. Comparison of Temperature with respect to speed

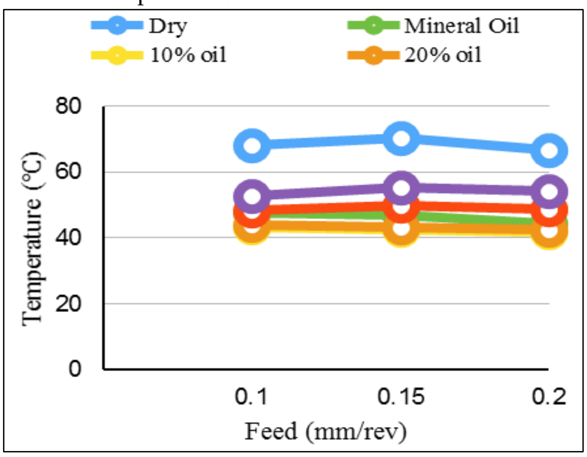
It can be clear that the machining in dry condition produced maximum temperature. Graph shows for the 0.5 mm depth of cut and 0.1 mm/rev speed. The tool work piece interface temperature is maximum in dry condition; coconut oil based cutting fluid having 40% oil concentration comes next, then comes the coconut oil based cutting fluid with 30% oil concentration after that mineral oil based fluid and the minimum temperature at tool work interface is observed in machining using coconut oil based cutting fluid having 10% and 20% oil concentration. The thermal conductivity of coconut oil based cutting fluid with 10% and 20% oil concentration is higher than mineral oil based cutting fluid which helps in easy heat removal and helps in producing superior cooling effect.





E. Comparison of Temperature with respect to feed

The variation of temperature at tool work interface with feed at 120 m/min speed and 0.5 mm depth of cut shown in graph. The temperature produced at tool work interface is maximum in dry condition and minimum for coconut oil based cutting fluid with 10% and 20% oil concentration. As feed increases the temperature decreases slightly so that minimum feed gives lower temperature.



F. Comparison of Temperature with respect to depth of cut

Variation of temperature at tool work interface at 120 mm/min speed and 0.1 mm feed for different cutting fluid shown. From the experiments, it is clear that the temperature increase with increase in depth of cut. So that as depth of cut increases, the temperature at tool work interface increases. For all different depth of cut the coconut oil with 20% and 10% oil concentration have low tool work interface temperature.

During machining more importance is given for obtaining required surface finish and minimizing the surface temperature in order to reduce the tool wear. From all 6 results conclude that the best machining condition at high speed and low feed and low depth of cut to gain better result. Cutting fluids are used in order to improve the surface finish and to reduce the tool wear. Considering these conditions the cutting fluid should help to improve the surface finish and should reduce the temperature at tool work interface. From this study among the new coconut oil based cutting fluid developed the fluid with oil concentration of 20% produced better performance both in case of improving surface finish as well reducing the temperature at tool work interface. In almost all condition this fluid performed superior to mineral oil based cutting fluid.

VII. Conclusion

Coconut oil based emulsion prepared by mixing oil and water with the help of a suitable emulsifying agent the main properties of the cutting fluid like viscosity, thermal conductivity, relative density and pH is also measured for each concentration of coconut oil in water emulsion and is also compared with commonly used mineral oil based cutting fluid.

The experimental study carried out on a CNC lathe for turning operation of EN 19 Steel. Cutting speed, feed rate, depth of cut and type of cutting fluid are as selected as process parameters. Surface finish and tool work interface temperature selected as responses. 162 experiments were carried out to collect the data.

Experiment shows that the coconut oil based cutting fluid with 20% oil concentration shows better performance than other fluid during machining. All the developed cutting fluid except fluid with the coconut oil based cutting fluid with 40% oil concentration shows a comparable or better performance with mineral oil based cutting fluid.. Machining using the coconut oil based cutting fluid with 20% and 30% oil concentrations gave better surface finish than mineral oil based cutting fluid.

Machining using the coconut oil based cutting fluid with cutting fluid with 10% and 20% oil concentration showed lesser value of temperature at tool work interface. The viscosity values of the coconut oil based cutting fluid with cutting fluid with 10% and 20% oil concentrations gives comparable result with mineral based cutting fluid. But the value of other two concentrations was more than that of mineral oil based cutting fluid. Since concentration of oil in emulsion increases the viscosity of emulsion also increases. The thermal conductivity of the coconut oil based cutting fluid with cutting fluid with 10% oil concentration is superior to all other fluids. The thermal conductivity of fluid increases with decrease in oil concentration in an emulsion. All the cutting fluid developed is basic in nature which a desirable property of cutting fluid.

Overall cutting fluid with 20% oil concentration is having better performance than all other varieties. Since both surface roughness and tool work interface is minimum. The reduced surface roughness and tool wear is due to the combined effect of both viscosity and thermal conductivity. As the oil content in emulsion increases viscosity increases and hence the lubrication increases but the thermal conductivity decreases. The water content in emulsion enhances thermal conductivity. Considering these facts in both aspects cutting fluid with 20% oil concentration shows better results. So the coconut oil based cutting fluid can be utilized as a suitable and possible alternative for mineral oil based cutting fluid considering the environmental issues and wastage accumulation.

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