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Experimental Study of Different Bio Based Cutting Fluid using Multiple Machining Characteristics during Turning Operation

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Abstract*: Cutting fluids are extremely important in the machining industry. In order to increase tool life and product quality in machines, cutting fluids are typically utilised to decrease friction. Mineral oil is utilised as cutting fluid in manufacturing. However, its use has detrimental impacts on human health, even in the workplace. These negative impacts are evident when turning. There has been research done to replace mineral oils with bio oils. Bio oils are simply readily available, vegetable-based oils, many of which are also edible. To comprehend the machining process of three distinct metals—MS, EN08, and STAINLESS STEEL—against three various bio-oils—SUNFLOWER, SOYA-BEAN, and COCONUT as lubricants, parametric studies using experimental techniques are conducted. It is clear from the plotted graphs that utilising soybean oil as CF2 results in a higher reduction in surface roughness than using coconut oil as CF3, sunflower oil, or both as CF1. Additionally, using sunflower oil as CF1 results in a bigger drop in cutting temperature than using soybean oil as CF2, while coconut oil as CF3 results in a greater reduction than all three metals together. The results showed that bio-oils had superior outcomes than mineral oils and have the qualities of a good cutting fluid. These bio-oils are more biodegradable and sustainable. Thus, they are said to as eco-friendly. By adding additives and nano particles, bio-oil may be furthermodified to have better lubricating characteristics.

Keywords: Cutting Fluids (CF), Cutting Temperature, Machining, Surface Roughness, Tool Life, Turning.

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1. INTRODUCTION

The friction and high temperature that are created during the machining process of a work piece will impact the chisel wear and product quality, as well as enhance the work piece's surface roughness [1]. The cooling technique is a way to lessen frictional force, wear, and enhance surface work piece [3]. The use of metal cutting fluids increases the tool life expectancy and surface quality of the material being machined by reducing friction and wear between two moving elements [2]. Additionally, metal cutting fluid greatly lowers the strength and energy requirements. Cutting fluids made of minerals offer many advantages, but they also have negative effects on human health and the environment. Mineral-based cutting fluids can cause irritation of the skin, lungs, eyes, nose, and throat, as well as cutaneous and airborne exposures. Exposure to mineral oil-based cutting fluids has also been linked to a number of other diseases, including obesity, asthma, pneumonia, and several cancers[10]. The main issue with mineral oil-based cutting fluids is specifically the improper management that leads to surface and groundwater contamination. Use of organic lubricants, vegetable lubricating oils, and other alternatives are some examples of these [11]. Vegetable oil is now possible to replace petroleum-based polymeric products due to the rising need for renewable resources [12]. Vegetable oil-based cutting fluid has been utilised successfully in a range of machining operations because it performs extremely efficiently as a lubricant. In order to employ environmentally friendly cutting fluids, we have used vegetable- based cutting fluids here for metal. For the goal of cutting fluid and mineral oil substitution, we evaluated two machining characteristics in our experiment: surface roughness and cutting temperature for three distinct bio oils (sunflower, soya bean, and coconut).

Experiment Details:
We have chosen three bio oils; sunflower, soya bean & coconut oil On the basis of availability,



cheap cost and market availability

Fig : soya bean oil (500ml) fig : sunflower oil(500ml) fig : coconut oil(500ml)

We have chosen three different steel materials; mild steel, EN08 & stainless steel on the basis ofeasy machinability, availability

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fig : MS round bar fig : EN08 round bar fig : stainless steel round barApparatus: manually operated lathe machine, roughness tester PCE-RT-11, temperature measuring wires,lcd

fig : lathe machine fig : PCE-RT-11 fig : lcd display fig : wires

We employed a high-speed lathe equipment to carry out the turning operation on the chosenmetals.

On three distinct feeds, the turning procedure was carried out for each metal and each fluid.

Every time we finished turning a metal for a certain feed, we used a roughness tester to measurethe surface roughness, and wires and an LCD temperature tester to measure the cutting temperature.
When turning, elongated chips can become a threat and a safety danger, therefore we handlethem carefully with gloves, a cutter, and tongs.

We used the mean of those measurements, which varied, to determine

With the aid of MS Excel, we finally plotted feed vs. roughness and feed vs. cutting temperaturegraphs to obtain a superior understanding.

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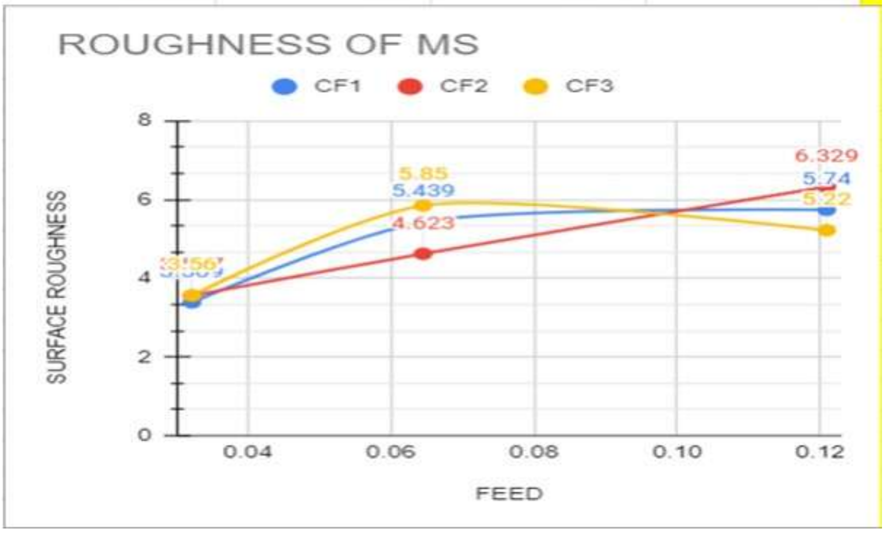
2. RESULT AND DISCUSSIONS:

MS

MS			
	SURFACE ROUGHNESS		
FEED	CF1	CF2	CF3
0.1209	5.74	6.329	5.22
0.0645	5.439	4.623	5.85
0.0322	3.389	3.557	3.56



Graphical analysis:

In our experiment, we plotted surface roughness vs. feed curves while holding speed & depth of cut constant. The results are as follows:

1) The surface roughness vs. feed curve for CF2 exhibits a linear kind of elevation, but the curves for CF1 and CF3 constantly decline after decreasing to a given feed.
2) For high feed (f > 0.12), CF2 roughness is higher than CF1, and CF3 roughness is higher than CF1. (CF2>CF1>CF3) is the decreasing order of surface roughness
3) For medium feed (.06f–.08), CF3 displays rougher surfaces than CF1, and CF1 displaysrougher surfaces than CF2. The order is decreasing: (CF3>CF1>CF2).
4) For low feed, CF2, CF3, and CF1 all exhibit roughly the same levels of surface roughness. (CF3>CF1>CF2)
5) For the feed (f=0.10), three CFs exhibit almost the same level of surface roughness. This roughness is smaller than the roughness for high feed and mid feed, in comparison.

ENO8

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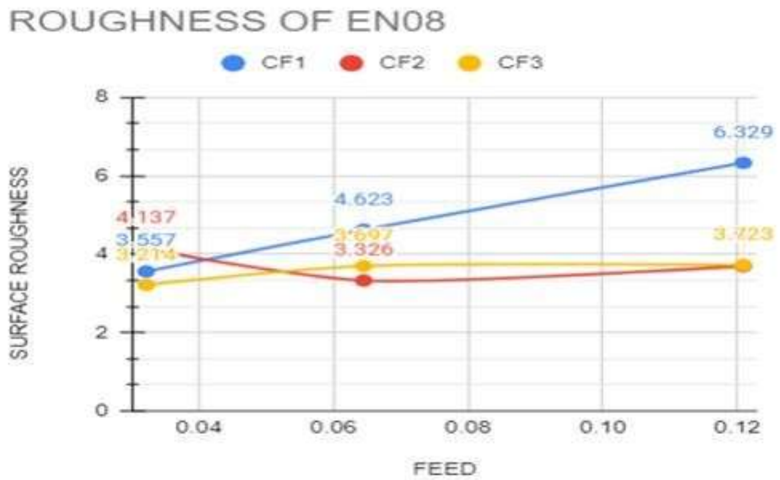
Graphical Analysis:

EN08			
	SURFACE ROUGHNESS		
FEED	CF1	CF2	CF3
0.1209	6.329	3.695	3.723
0.0645	4.623	3.326	3.697
0.0322	3.557	4.137	3.214



1. the surface roughness vs feed curve for CF1,CF3 shows linear elevation, whereas CF2 shows max roughness at start then continues to decrease at certain feed (.06<f<.75) thenremains constant throughout
2. For high feed (f>0.12) CF1 shows max surface roughness, whereas roughness for CF2,CF3 is more or less the same . CF2<CF1>CF3
3. for medium feed (.06<f<.08) CF1 shows greater surface roughness than CF3 and CF3 shows more roughness than CF2. CF1>CF3>CF2
4. for low feed CF2 shows greater roughness than CF1, CF1 shows more roughness than CF3. CF2>CF1>CF3
5. for feed (f >= 0.04) CF1,CF2 shows same roughness value
6. for feed (.06<f<.075) CF3,CF2 shows the same roughness.

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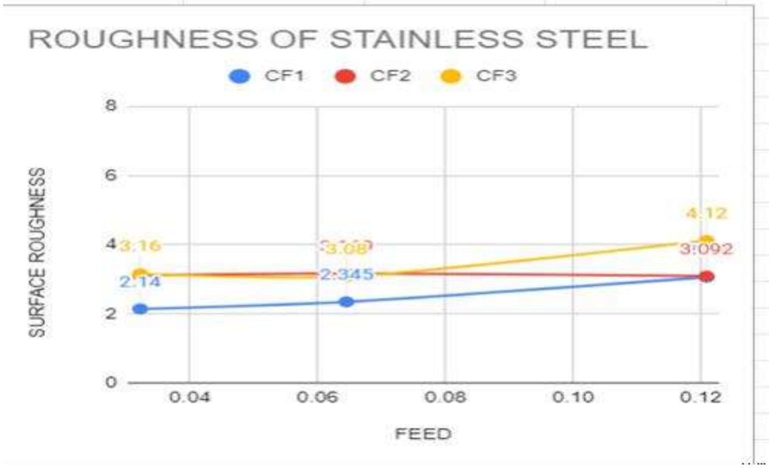
STAINLESS STEEL			
	SURFACE ROUGHNESS		
FEED	CF1	CF2	CF3
0.1209	3.06	3.092	4.12
0.0645	2.345	3.169	3.08
0.0322	2.14	3.11	3.16



STAINLESS STEEL

Graphical Analysis:

1. the roughness curve for CF3,CF1 is of the same nature. They increase with a slow rate w.r.t feed,whereas the roughness curve for CF2 remains constant for feed f <=.075 thendecrease at slow rate
2. for high feed (f>.12) CF3 shows max roughness than CF2 anf CF2 shows more than CF1.CF3>CF2>CF1
3. for medium feed (.06<f<.08) CF1 shows less roughness compared to CF2 ,CF3. CF2>CF3>CF1
4. for low feed (f<= .04) CF3 shows more roughness than CF2 and CF2 show more than CF1. CF3>CF2>CF1

Observations for surface roughness:

From the graphical analysis of three different materials MS,EN08, STAINLESS STEEL weobserve following things:

1. Minimum surface roughness can be achieved for MS, ENO8 by using CF2 i.e, soybeanoil
2. For stainless steel minimum surface roughness is achieved by using CF1 i.e, sunflower oil. This happens due to material properties and ductility measure of stainless steel is fardifferent from MS & EN08
3. For high feed CF3 i.e, coconut oil gives low surface roughness for different metals used.
4. For low feed sunflower oil gives minimum surface roughness for ms, EN08, stainless steel.

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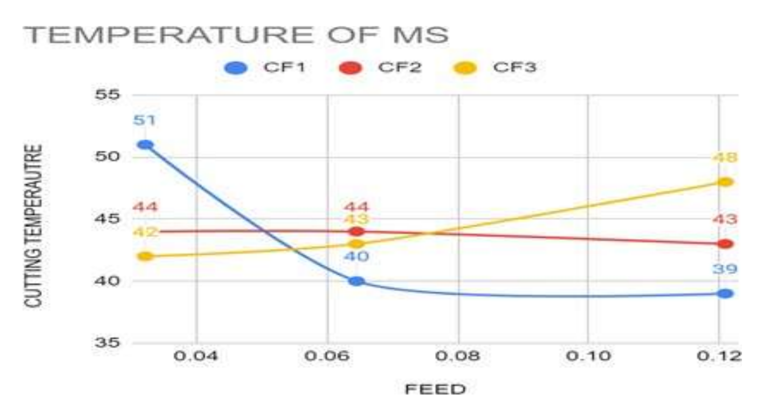
Cutting Temperature:

MS



	CUTTING TEMPERATURE		
FEED	CF1	CF2	CF3
0.1209	39	43	48
0.0645	40	44	43
0.0322	51	44	42

Graphical analysis:
In our experiment, we plotted curves on cutting temperature vs feed keeping speed & depth ofcut as constant, we get the following observation

1. The cutting temperature vs feed curve for CF1 shows decreases continuously to medium feed,then remains constant through out.The curve for CF2 remains constant upto feed (f<=0.075) first then decreasesat slow rate.The curve for CF3 increases.
2. for high feed (f<0.12) cutting temperature for CF3 is the highest than CF2 & CF2 is greater than CF1. CF3>CF2>CF1
3. for medium feed (.06<f<.08) the cutting temperature for CF2 is higher than that of CF3 & CF3 is greater than CF1. CF2>CF3>CF1
4. For low feed the temperature for CF1 is greater than CF2 & CF2 isgreater than CF3. CF1>CF2>CF3

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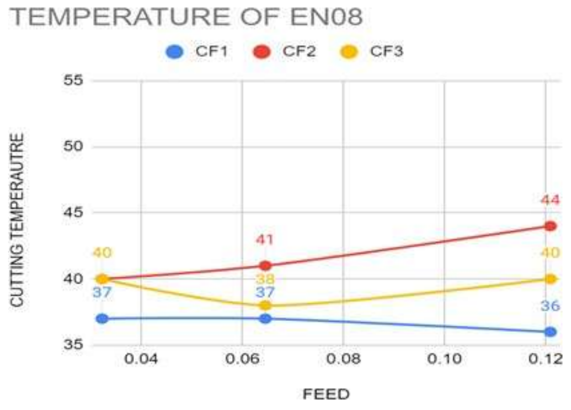

EN08			
	CUTTING TEMPERATURE		
FEED	CF1	CF2	CF3
0.1209	36	44	40
0.0645	37	41	38
0.0322	37	40	40

Graphical analysis:

1. The cutting temperature vs feed curve for CF1 shows gradually decreases.The cutting temperature vs feed curve for CF2 shows gradually increases.The cutting temperature vs feed curve for CF3shows decreasing and then increasing.
2. for high feed (f <0.12) cutting temperature for CF2 is higher than CF3 & CF3 is greater than CF1. CF2 > CF3 > CF1
3. For medium feed (0.06<f<0.08) the cutting temperature for CF2 is higher than that of CF3 & CF3 is greater than CF1. CF2>CF3>CF1.
4. for low feed rate temperature of CF2 is greater than CF3 & CF3 isgreater than CF1. CF2>CF3>CF1.

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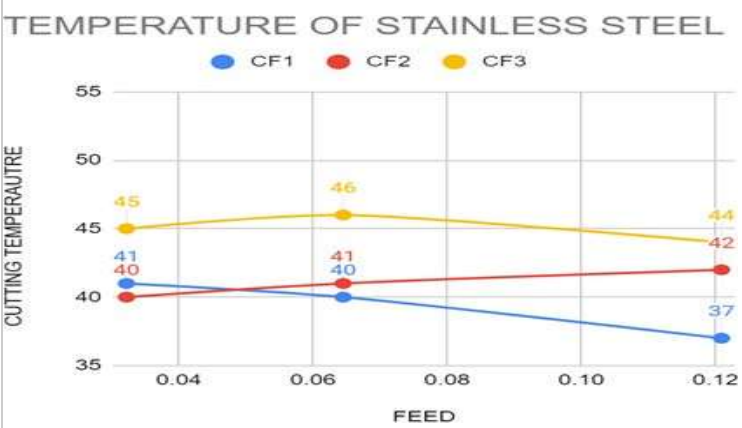
STAINLESS STEEL



	CUTTING TEMPERATURE		
FEED	CF1	CF2	CF3
0.1209	37	42	44
0.0645	40	41	46
0.0322	41	40	45

Graphical analysis:

1. The cutting temperature vs feed curve for CF1 shows gradually decreases.The cutting temperature vs feed curve for CF2 shows gradually increases.The cuttingtemperature vs feed curve for CF3 shows increases and then decreases.
2. for high feed (f <0.12) cutting temperature for CF3 is higher than CF2 & CF2 is greater than CF1. CF3 > CF2 > CF1
3. for medium feed (0.06<f<0.08) the cutting temperature for CF3 is higher than that of CF2 & CF2 is greater than CF1. CF3>CF2>CF1.
4. for low feed rate temperature of CF3 is greater than CF1 & CF1 is greater than CF2. CF3>CF1>CF2.
5. CF1 &CF2 intersect at a feed point 0.05 & 41 in cutting temperature.

Observations for cutting temperature:-
From the graphical analysis of three different materials MS,EN08, STAINLESS STEEL weobserve following things:

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1. Minimum temperature can be achieved for MS, ENO8 & stainless steel by using CF1 i.e,sunflower oil
2. Maximum temperature can be achieved for MS & stainless steel by using CF3 i.e, coconut oil
3. For EN08 maximum temperature is achieved by CF2. i.e, soybean oil.
4. CF2 i.e, soybean oil gradually increases in EN08 & stainless steel, but in MS it shows aproperty of gradually increasing.

3. CONCLUSION

Using bio oils as cutting fluids not only reduces surface roughness but also reduces the cutting temperature. From the data analysis we can observe that bio oils surely can take place of mineral oils .Mineral oils being harmful for both nature and human health, are not preferable for cutting operation. Whereas bio oils being economic, cheap, easily available, ecofriendly clearly serves the purpose of cutting fluids in machining. Hence bio oils are better option to be used as cutting fluids rather than petroleum & mineral based fluids.

Futurescope

1. As the bio oils are economical and cheap cost, they can be easily available from the market.
2. Bio oils are non-corrosive and do not oxidize in contact with air, hence they can be contained for a long time.
3. The bio oils show considerably better lubrication property and also reduce cutting temperature while machining in comparison to mineral oils and petroleum based cuttingfluids.
4. The bio oils have comparatively high fire point than mineral based cutting fluids hencefire hazard caution will be less
5. The bio oils does not emit toxic, harmful gasses while applying in cutting operation, hence they can be used as ecofriendly substitution of mineral oils & petroleum based cutting fluids.

From our data captured and graph plotted, it can be clearly seen that bio oils can be certainly used as cutting fluids for the above reasons .There are huge potential for the bio oils to be used as cutting fluids for different machining operation in near future.

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