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Utilizing bio coolants for experimental investigation of Surface Finish and Temperature Variations in Machining Operations

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ABSTRACT

Due to their adequate lubricating characteristics on both the workpiece and the cutting tools, mineral oils have traditionally been used as the conventional source of cutting fluids in the machining of a variety of metals and alloys. However, employing these oils as lubricants in the majority of modern applications comes with certain difficulties. Recent times have seen a shift in emphasis towards bio-based lubricants due to environmental concerns. Plant oil is converted into bio lubricants using a variety of chemical modifying processes. Bio-lubricants are an excellent substitute for mineral-based oils since vegetable oils are more lubricating and environmentally beneficial. In this regard, an experiment is carried out to determine the efficiency of various bio-based metal cutting fluids (MCF), which are crucial to the machining process and have an impact on it. The primary goal of this study is to demonstrate that bio coolant is a real substitute for petroleum and mineral oil lubricants. The efficacy of the bio coolant is evaluated in turning and drilling operations. An improved results are observed in the tool tip temperature and specimen surface finish in both drilling and turning operations.

KEYWORDS: Lubricants, Metal cutting fluids, Bio-coolant, Tool tip temperature, surface finish

INTRODUCTION

Quality has always captivated the human race. The technology of today is evidence of man's never-ending drive to offer goods and services at a better caliber in order to gain market share and profit. The lubricant has a major role in how well a given material is machined to its final product. The cost of the lubricant is about 60% of the total cost of manufacturing a product. The yearly output of lubricants is estimated to be between 30 and 40 million tons, and they are used in a wide range of industrial applications to reduce frictional heat, guard against corrosion and wear, transfer energy, remove impurities, and perform sealing procedures, among other things [1]. According to reports, between 50 and 75 percent of the world's lubricant output gets released into the environment indiscriminately [1]. Approximately 95% of all lubricant manufacturing is based on petroleum, often known as mineral oil [4]. These formulations are poisonous and non-renewable in a way that makes the lubricants dangerous for people to use. Bio lubricants on the other hand, degrade more quickly and easily, having a smaller negative impact on the environment. Despite the lubricants' high toxicity, there were reports of lubricants discharge that severely contaminated the air, soil and drinking water. This means that the lubricants made from mineral oils traditionally used in place of them might potentially be replaced by bio-based sources, also known as "bio lubricants" [5]. Bio lubricants have excellent physical and chemical properties [3]. Due to their renewable nature and ease of degradation into safe byproducts, widely used in industry as emulsifiers, lubricants, plasticizers, and surfactants, solvents, plastics and resins. Bio-coolants made from plant oils should offer the following advantages and disadvantages:

(i) Greater lubricity results in less friction loss, more power, and improved fuel efficiency.
(ii) Less volatile fuels provide less exhaust pollutants.
(iii) Higher viscosity.
(iv) Higher shear stability.
(v) Greater detergent efficiency eliminates the need for additives in detergent.
(vi) Greater dispersion
(vii) Rapid biodegradation, which results in less environmental and toxicological risks.
(viii) Longer tool life
(ix) Aids in emulsifying debris, maintains clean work areas.[2]

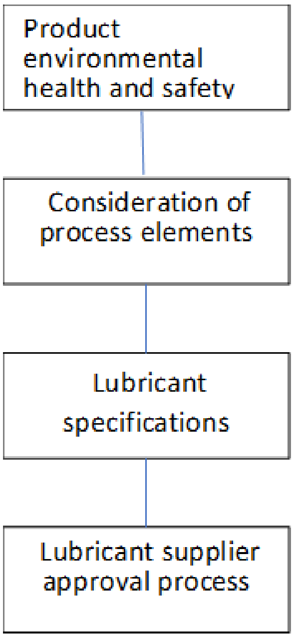

Figure 1**:** Lubrication Selection Strategy

(redrawn from reference [6])

Disadvantages

i. Oxidative stability
ii. High freezing points
iii. Poor corrosion protection

OBJECTIVES

This objective of this work is to demonstrate that bio coolants are superior than mineral oil-based lubricants because they have greater lubricating characteristics, which produce higher surface finishes and temperature-lowering abilities. Race is on to find cheaper, better and more friendly environmental lubricant for all engineering applications. We have used the blend of edible and non edible oils. High viscosity can lead to issues including slow motion, higher mechanical friction, and heat production. The delivery of coolant comes in a variety of pressure and property combinations. Inaccurate coolant pressure can seriously harm the product. Choosing the optimum lubricant supply method has a significant influence on producing better-machined goods.

Experimental Work

The performance of bio-coolants in drilling of 6061 Aluminium plates and turning of 6061 Aluminium rod is carried out on Radial drilling Machine and Conventional flat bed Lathe respectively. Four different ways of machining is performed viz., Dry Machining and Wet Lubrication using various coolants. Four rods of 30mm diameter and 150mm length is used in turning and Four plates of 15mm thickness are used in drilling. In both turning and drilling initial operations are performed without any lubrication(Dry Machining) and later using mineral oils and the biologically prepared oils as the coolants. Tool tip temperature and the surface roughness were recorded and studied for each trial.

Preperation of the Bio-Coolant

Two types of coolants were prepared one using Coconut oil and Cotton seed oil (COCS) and other blend is using Coconut Oil and Neem Oil (CONO)

Coconut Oil and Cotton seed are taken at 1:1 ratio heated mildly, combined together in beaker and stirred using a manual stirrer. In the same manner Coconut oil and Neem Oil are blended to form another mixture.

1. Coconut oil: The wick, flesh, and milk of the coconut palm fruit are used to make coconut oil.

Figure 2: Coconut oil

2. Neem oil: Neem oil, sometimes referred to as margosa oil, extracted from the neem tree's fruits and seeds (Azadirachta indica).

Figure 3: Neem oil

3. Cottonseed oil: Oil made from the seeds of many types of cotton plants is known as cottonseed oil.

Figure 4: Cottonseed oil

Figure 5: Properties of oils

Type of oil	Density (kg/cm^3)	Viscosity(cP)	Fire point(^{0}F)	Flash point(^{0}F)	Freezing point(^{0}C)
Coconut oil	920	30	350	420	25
Neem oil	965	48.5	420	464	16
Cottonseed oil	933.3	24	420	582	26
Mineral oil	890	95-100	-	440	-22

Work Piece Material

One of the most frequently used Aluminium alloys is type 6061 Aluminium. Numerous general-purpose applications are suitable for it due to its weldability and formability. Type 6061 alloy is particularly helpful in architectural, structural, and automotive applications because to its high strength and resistance to corrosion. Due to its various engineering application test are conducted on 6061 Al alloy.

1. Alumium plate: Aluminium plate is 200*100*15 in size.

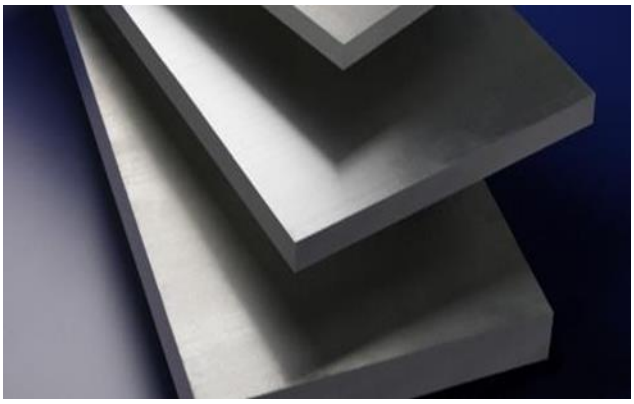

Figure 6: Aluminum plate

2. Aluminum rod: Aluminum rod with dimensions of 150 mm in length and 30 mm in diameter.

Figure 7: Aluminum rod

Figure 8: Infrared thermometer

Figure 9: 25mm drill bit made of high speed steel

Figure 10: Single point cutting tool

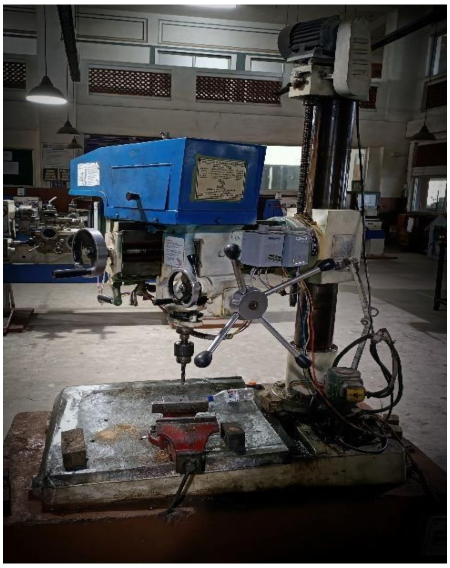

Figure 11: Radial drilling machine

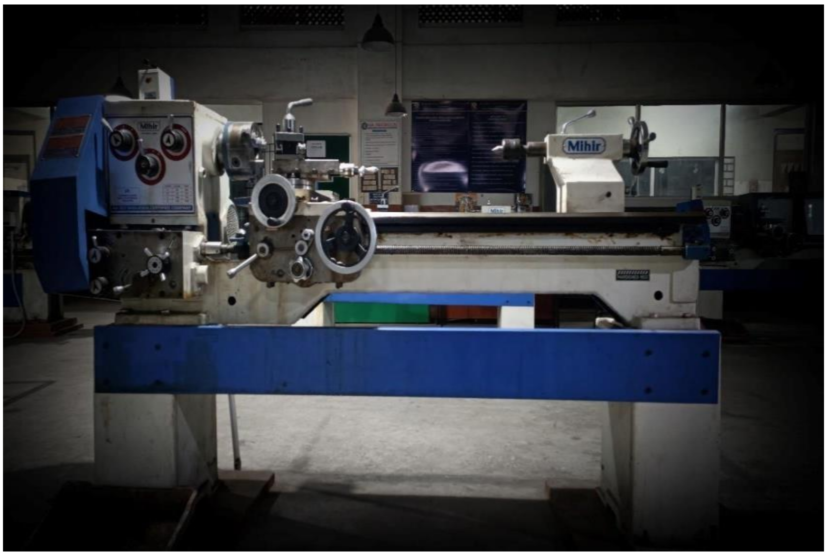

Figure 12: Single bed lathe

Mitutoyo 178-561-02A Surf test SJ-210 Surface Roughness Tester (Taly surf)

Taly Surf is a surface meter that includes a stylus and a skid type device used for measuring the surface of the given product. This particular model of Taly surf surface meter has an electronic component that makes it more precise and accurate than other surface meters. The measuring head has a diamond stylus on it that is extremely pointed. in taly, the surf is up. The motor within the meter stylus helps to move the skid over the surface, and it has a very tiny radius tip (0.002 mm). In this device, the stylus marks the surface's profile, and any deflections of the pen are turned into an electric current to determine the object's measurements.

Figure 13: Surface roughness tester

Blending of bio coolants

1. An equal proportions of Coconut oil and Cottonseed oil (COCS) are blended together.

Figure 14: Blend of coconut oil and cottonseed oil

2. An equal proportions of Coconut oil and Neem oil (CONO) are blended together

Figure 15: Blend of coconut oil and neem oil

Operation on Drilling Machine

The tool holding device has a 25mm drill bit placed inside it. The machine is set up in the proper position to drill the hole. Holes are drilled on the specimen at four different conditions which are i) dry machining ii) using mineral oil as coolant iii) using COCS blend iv) using CONO blend. Tool tip temperatures and specimen temperatures are recorded each time by using infrared thermometer. The specimen must cool to room temperature before next drilling. After completion of drilling holes, the specimen is cleaned with cloth and kept aside withoutdisturbing the surface.

Figure 16: Drilling operation with 25mm drill bit on flat Al plate of 15 mm thickness

Operation on Lathe Machine

The Aluminium circular rod is fixed in the three-jaw chuck and Single point cutting tool is mounted to it. Aluminium rods are machined at three different conditions which are i) dry machining ii) using mineral oil as coolant iii) using CONO blend. The tool tip and specimen temperatures are recorded each time by using infrared thermometer. After completion of operation, the specimen is cleaned with cloth and kept aside withoutdisturbing the surface.

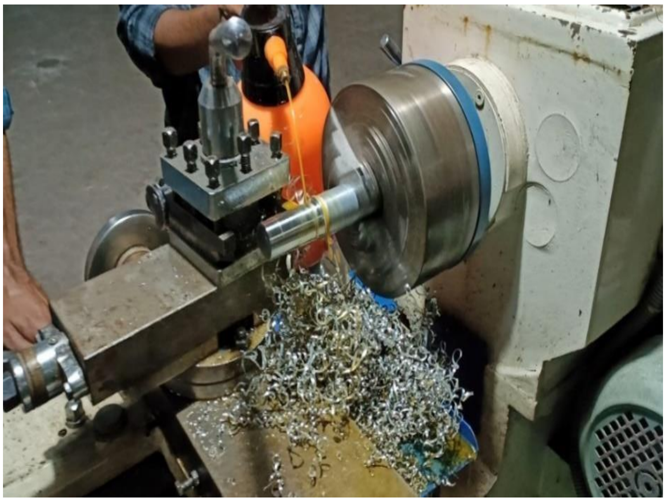

Figure 17: Turning operation with single point cutting on aluminium rod of 30mm diameter

Performing Surface Roughness test on specimens

To determine surface roughness, we need to understand three concepts.

1. Ra **-** Average Surface roughness
2. Rz **-** Vertical Distance from peak to valley
3. Rq **-** Average maximum height of the profile

Ra: The arithmetic average roughness value Ra describes the arithmetic average of all deviations in the roughness profile from the median line within the measuring length

Rq: Root mean square deviation, abbreviated as is Rq, shows the root mean square along the sampling length. Rq is referred to as the root-mean-square roughness for the roughness profile.

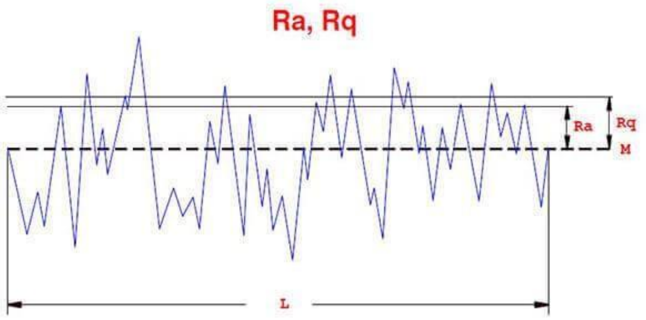

Figure 18: Ra,Rq

Rz: It is the average of the absolute values of the heights of the five peaks with the greatest visibility and the depths of the five alleyways with the greatest depths within the assessment length.

Figure 19: Rz

RESULTS

Calculations of Surface Roughness(Ra)

Surface roughness values were recorded at different areas on the specimen surface for each of the machining conditions and mean values of the readings are being recorded.Fig 20 and Fig 21 shows the Ra values of the drilled holes and the machined surface of the Al rod respectively.

Coolant	Surface roughness values (Ra)	Average values (Ra)
	3.504	
	2.197	
	2.719	
	3.380	
	2.209	
	3.118	
	4.509	
	1.392	

Figure 20: Surface Roughness Values obtained on the surface of holes

Coolant	Surface roughness values (Ra)	Average values (Ra)
	0.429	
	0.366	
	0.543	
	0.550	
	0.658	
	0.671	
	0.667	
	0.601	
	1.048	

Figure 21: surface roughness values obtained on the surface of Al rods

An improved surface is observed on drilled hole i.e., Ra =2.655 and machined surface of Al rod i.e., Ra = 0.466 for the Blend of CONO when compared to other coolants that are considered. Graphs are plotted based on the recorded Surface Roughness values (Ra) of drilled holes as shown in the figure 22 and machined surface of Al rod as shown in the fig 23 respectively.

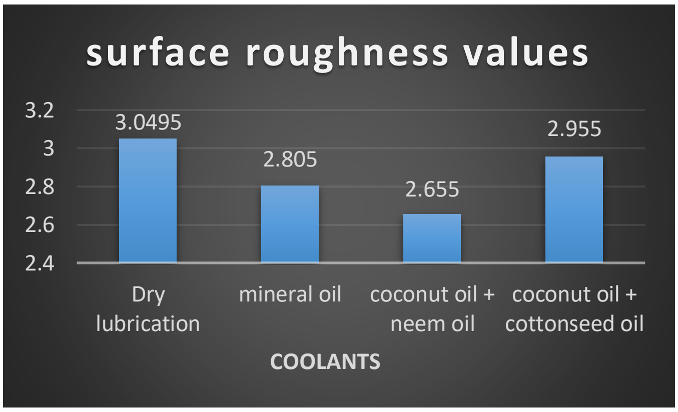

Figure 22: Surface Roughness values with various coolants

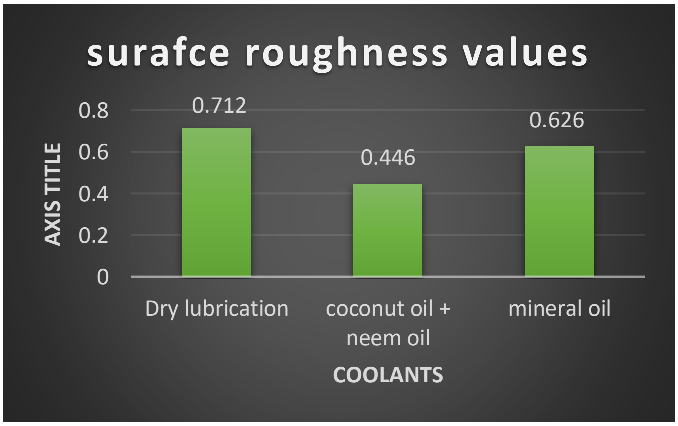

Figure 23 : Surface Roughness values with various coolants

Tool tip and Specimen temperatures

Tool tip temperatures and specimen temperatures were recorded for each of the machining conditions by using infrared thermometer. Fig 24 and Fig 25 shows the recorded temperatures of the Aluminium flat plate and Aluminium rod during drilling and turning operations respectively.

Coolants	Tool tip temperatures	Specimen Temperature
Dry machining	78	69.4
Blend of CONO	58.6	54.6
Blend of COCS	62.3	57.8
Mineral oil	61.7	56.9

Figure 24: Recorded tempertatures of Al flat plate

Coolants	Tool tip temperatures	Specimen Temperature
Dry machining	48.2	51.6
Blend of CONO	42.3	45.8
Mineral oil	47.4	46.6

Figure 25: Recorded temperatures of Al rod

It is found that the Tool tip temperatures and Specimen temperatures are less for the blend of CONO during drilling and turning operations when compared to other coolants that are considered. Graphs are plotted based on the recorded tool tip temperatures and specimen temperatures during drilling operation as shown in Fig 26 and during turning operation as shown in Fig 27 respectively

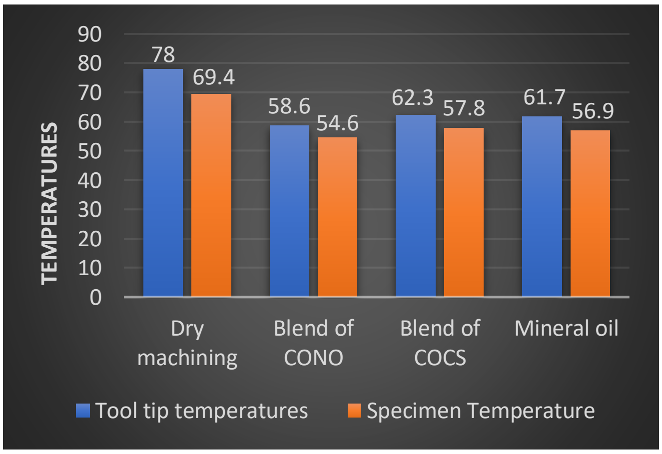

Figure 26: Recorded temperatures with various coolants

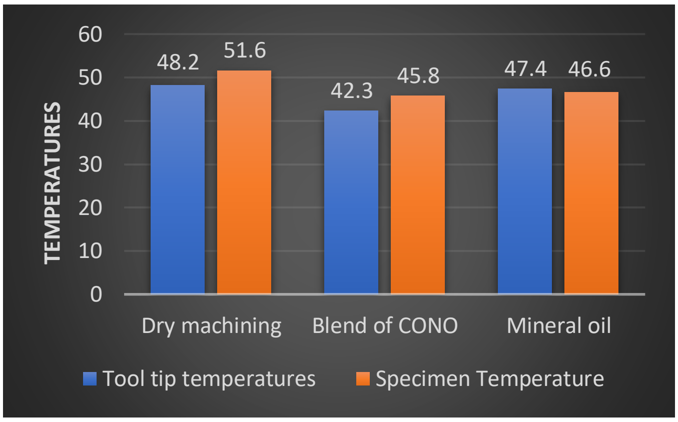

Figure 27: Recorded Temperatures with various coolants

CONCLUSION

The examination of several bio coolants effects on temperature regulation and surface roughness during machining operations produced the following conclusions.

- The analysis of Bio coolants has been done using the flood lubrication method on drilling and turning operations.
- It is found that along with cutting speed and depth of cut, coolant places a significant role on surface finish of the machined components.
- From the experimentation results, it is observed that Bio- coolant **blend of CONO** produces lower tool tip temperatures, specimen temperatures and better surface roughness values when compared to other coolants that are considered. By considering all advantages with Bio coolants, it is observed that the Bio coolants are safer than mineral oils and also the results obtained by the experimentation are quite better than compared to mineral oil.

FUTURE SCOPE

- Although advantages, challenges are faced in producing and storing of bio- coolant.
- An Extensive study and elaborate research is still being done in this area.
- Lot of research is being done on use of nano additives in bio-coolants to reduce the machining temperatures.
- The same may be done in the above proposed blend of coolants for further improved results.

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