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Research Article

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Feasibility study on formulation of cutting fluid from waste palm oil

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ABSTRACT

From an industrial, environmental, and scientific standpoint, the creation of renewable and sustainable products to replace fossil fuels is an important concern in this decade. Due to the growing use of different lubricant types, the majority of which are mineral-based, there is an unavoidable flow of mineral-based lubricants into the environment. Another issue is using cooking oil that pollutes the environment when discarded. Both of these issues can be resolved by creating bio-based lubricants from discarded cooking oil. This article discusses formulating a green cutting fluid made from used cooking oil. This enables the use of waste oil as a cutting fluid while retaining its tribological and environmental characteristics. In order to compete in the market, biodegradable cutting fluid might gain from decreased costs for used natural oils. The many components and trends that make up this topic are briefly covered in this article, along with waste cooking oils' potential application as a bio-based lubricant.

KEYWORDS: Waste palm oil, Cutting fluid, Performance test

INTRODUCTION

Cutting fluid is a type of coolant or lubricant designed specifically for metal working processes such as machining and stamping (Yan *et al.*, 2015). Cutting fluid provides benefits such as extended tool life, dimensional accuracy, and good surface finish all of which contribute to high rates of production. Cutting fluid comes in a variety of forms such as oils, oil-water emulsions, pastes, gels, aerosols, air and other gases. Cutting fluids can be produced using petroleum distillates (Lawal *et al.*, 2014), water, air, plant oils, animal fats and other basic materials. The majority of the time, it is sent directly to the cutting zone, as near the cutting edge as possible where chip production occurs. To break and flush the chips out of the cutting zone, cutting fluids are typically provided under high pressure. When chips are efficiently broken down and eliminated, cutting fluid has better access to the cutting edge, resulting in the intended cooling and lubricating benefits Consequently, effective cutting fluid administration can aid in controlling cutting temperatures and reducing frictional contact. Reduced cutting force and cutting energy, as well as increases in surface finishing and dimensional accuracy are signs that thermo-mechanical wear on cutting tools is decreased, tool life is extended, and machining performance is improved (Diniz & Micaroni, 2007). Nowadays mineral oil-based cutting fluids are commonly used. Vegetable oil performs better when compared to mineral oil in terms of pollution (Shashidhara & Jayaram, 2010). They are biodegradable, non-poisonous, on - hazardous to the environment. Apart from being an eco-friendly cutting fluid vegetable oil-based cutting fluid also offers better machining performance by life and minimizing the cutting tool/workpiece interface temperature, friction and improving the surface finish by lowering the tool wear (Belluco & De Chiffre, 2004). Vegetable oil performs (Sankaranarayanan *et al.*, 2021) better when compared to mineral oil in terms of pollution. They are biodegradable, non-poisonous, on -hazardous to the environment.

However, a lack of raw resources and high production costs are the main problems introducing these biofuels and bioproducts. Thus, these flaws restrict the availability of finished items. In other words, the accessibility and cost of these vegetable oil raw materials become crucial for ensuring production competitiveness and availability for commercial purposes. So waste cooking oil can be used as a base stock for the production of cutting fluid to make it affordable. Industrial cooking waste is also a worldwide concern. Over 16.5 million tons of WPO are thought to be produced globally each year. India is the second-largest consumer of palm oil in the world. Around 40% of the total production of palm oil is expected to be used in the food industry every year. Due to its low solubility in water, the disposal of WCO poses one of the biggest issues since it pollutes the environment and the soil (Hosseinzadeh-Bandbafha *et al.*, 2022). Hence, in this project, waste palm oil (WPO) was selected as the base stock for the creation of cutting fluid (Al-Widyan & Al-Shyoukh, 2002). It will be environmentally friendly and a potential solution to the waste disposal issue. Energy generation by waste is considered one method of waste management that has the benefit of energy recovery. From the waste-to-energy point of view, waste cooking oil has been considered good candidates for feedstocks for energy conversion due to their high heating values. Animal fats and used cooking oil are readily available all throughout the world, especially in developed countries. Due to disposal concerns and the risk of contaminating land and water resources, managing these oils and fats is a difficult endeavor. The majority of this used cooking oil is discarded into the environment, though some of it is used to produce soap. The use of waste cooking oil to generate biodiesel (Hosseinzadeh-Bandbafha *et al.*, 2022) as a Petro diesel substitute offers significant environmental benefits because enormous amounts of waste cooking oils are illegally dumped into rivers and landfills, harming the environment, emissions of greenhouse gases (GHG) and other types of global pollution. According to Klass, emissions of NO2, SO2, CO, particulate matter, and volatile organic compounds (VOCs) are also primarily produced by petroleum-based diesel (Madanchi *et al.*, 2019). Due to their long-term persistence in the environment, the emission of such pollutants has negative effects on human health (Lodhi *et al.*, 2021) in addition to the environment at large. Making bio-based products from used cooking oil, which would otherwise be thrown away, is one of the most economical ways to do so. Utilizing leftover cooking oil greatly increases the economic viability of manufacturing bio-based products because the cost of feedstock is one of the major obstacles.

This study focuses on developing an eco-friendly water-based green cutting fluid from waste-cooked palm oil by using suitable emulsifiers and conducting a performance study of the prepared sample on the pin-on-disc tribometer.

MATERIALS AND METHODS

Materials

In this experimentation, Waste palm oil was collected from different shops in Trivandrum, Kerala, India. The Surfactants used in the work are Tween 80 and Span 80 series was procured from HIMEDIA Laboratories, Mumbai, India.

Tribological Property Evaluation

The sample's tribological characteristics, including wear scar diameter (WSD) and coefficient of friction (COF), are assessed using a four-ball tester. The ASTM D4172 standard was followed for the testing. The four-ball tester comprises an AC motor-driven vertical spindle with a ball collet (Figure 1). Using a torque wrench and a ball locking ring and a lock nut, the three balls are installed in the ball pot. An oil sample is placed in the pot. A heater is attached to the ball pot, which is positioned on top of the anti-friction disc. The balls received the standard load of 392 N from a loading lever. The balls have a 12.7 mm chrome steel core. The test was run for one hour at a rotating speed of 1200 rpm and a temperature of 75 °C.

Corrossion Stability

Using a copper strip corrosion tester with the model designation EIE-PTLT-105D as shown in Figure 2, the corrosion stability of WPO was evaluated in accordance with ASTM D 130. After being cleaned and dried, the copper strip is polished with sandpaper and silica powder. It is then put in a test tube with 30 mL of test samples so that the copper strip is completely submerged. The color of the copper strip is contrasted with the color after the test compared to the standard color code which is shown in Figure 3.

Emulsion Stability

An emulsion is formed by using surfactants such as Tween 80 and Span 80 in different proportions to the base oil which is shown in Table 1.

Pin on Disc Apparatus

Figure 4 shows the pin-on-disc test schematically. Under the applied load, the stationary pin is forced up against the

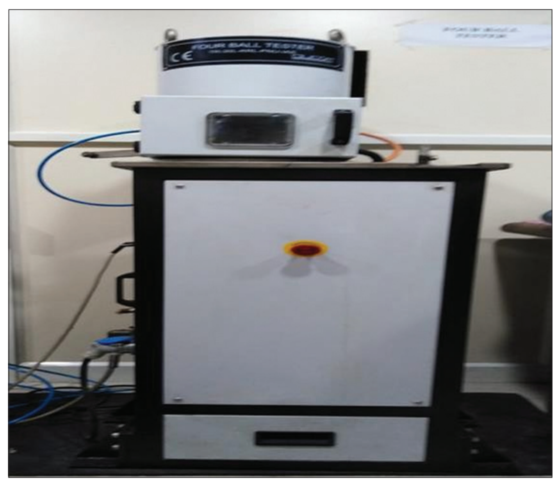

Figure 1: Four ball tester

Figure 2: Copper strip apparatus

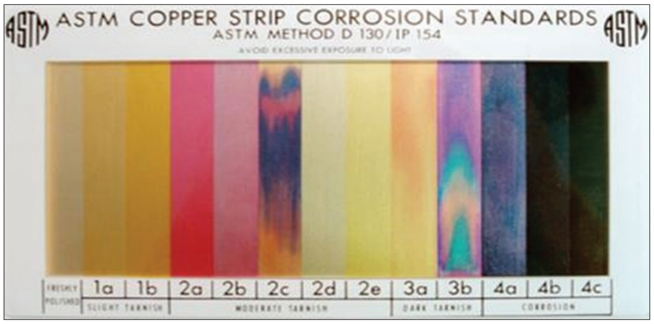

Figure 3: Standard color code

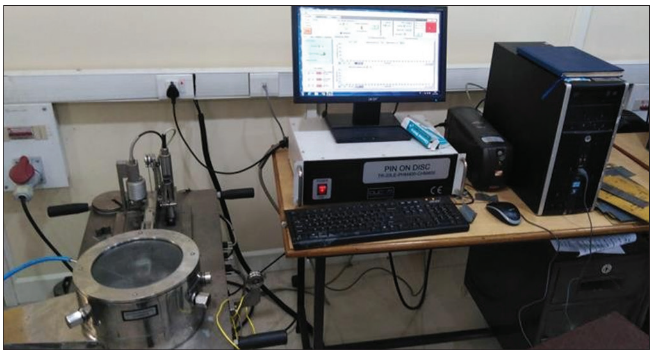

Figure 4: Pin on disc apparatus

Figure 5: Surface roughness measuring instrument

rotating disc. The pin can be any shape, although the most common shapes are spherical (ball or lens) or cylindrical due to the simplicity with which they can be aligned (flat pins are frequently vulnerable to misalignment, which can result in uneven loads and make theoretical analysis challenging). The COF is measured using the software attached to the system.

Surface Roughness Measurement

Surface roughness is measured by using Mitu toyo equipment which is shown in Figure 5. The first step is to remove dust and oil from the measuring target surface and adjust the surface in accordance with the probe extension of the equipment.

Figure 6: Corrosion stability

Table 1: Emulsion combinations

TWEEN 80	SPAN 80	OIL	WATER	SAMPLE
1.25	1.25	2.5	100	WPO-50
1	1	3	100	WPO-40
0.75	0.75	3.5	100	WPO-30

Table 2: Tribological Analysis

COF	0.044
WSD	573 µm

Table 3: Performance test results

S. No.	Speed (rpm)	COF	Surface roughness
1	200	0.16	0.152
2	400	0.13	0.163
3	600	0.18	0.174
4	800	0.17	0.158

RESULTS AND DISCUSSION

The following results are obtained from the tribological analysis and corrosion of WPO.

Tribological Analysis

From the results of four-ball testers, the WPO shows better tribological properties which is shown in Table 2.

Corrossion Analysis

The results from the copper strip corrosion apparatus prove the WPO has a lesser amount of corrosion than shown in Figure 6 so it can be used as a base oil for cutting fluids.

Performance Test

From the emulsion stability test, WPO-50 shows better emulsion stability, and by using that combination, the green cutting fluid is produced. The performance test was conducted according to ASTM G99 standards, and the roughness of the pin material is evaluated as shown in Table 3. The developed green cutting fluid performs better because it has a low COF and a good surface finish.

CONCLUSION

In this research, the following conclusions were obtained: 1) The waste palm shows better tribological properties and corrosive properties, 2) The best emulsion combination is identified as WPO-50 and 3) From the performance test results the green cutting fluid shows better properties.

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