Effect of Vegetable-Based Nanofluid Enriched with Nanoparticles as Metalworking Fluids During Orthogonal Cutting Process

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Abstract. The growing interest in the usage of vegetable oils as a based fluid for the lubrication industry led to more study on the potential of vegetable oils as MWFs to replace the mineral-based oil due to the environmental benefits such as renewable and biodegradable. In this study, vegetable-based nanofluids were formulated from modified jatropha oils (MJO) mixed with nanoparticle additives copper oxide and activated carbon at different concentration of 0.01, 0.025 and 0.05wt.%. The aim of this study was to evaluate the machining performance of the nanofluids (MJOc1, MJOc2, MJOc3, MJOa1, MJOa2 and MJOa3) compared with the commercial synthetic ester (SE)in terms of cutting temperature and chip thickness. The lathe machine (Harrison alpha 400) was used for orthogonal cutting with the minimum quantity lubrication (MQL) method. Thermal imager camera FLIR T640 used in this experiment to measure the maximum cutting temperature by placing the camera in an axial direction during the machining process. Then, a micrometre (model: Mitutoyo IP 65) used in this experiment to measure the chip thickness while a tool maker measuring microscope used to measure the tool chip contact length after the experimental process. MJO with nanoparticle additions has the potential to replace SE as a long-term metalworking fluid.

Keywords: Modified jatropha oil · Nanofluid · Nanoparticle · Metalworking fluid

1 Introduction

Mineral oil, synthetic oil, and vegetable oil are among the MWF's sources. Tribological characteristics such as friction, lubrication, and wear mechanism play an essential role in choosing the right MWF [1]. Vegetable oil is renewable and biodegradable, it is beneficial for the environment. Because of its low thermal and oxidative stability, vegetable oil is regarded as a lubricant that underperforms [2]. Vegetable oil, on the other hand, must be treated before usage in order to improve its limitations in terms of oxidation stability,

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high friction, high viscosity, heat stability, and corrosion resistance [3]. To improve vegetable oil, many studies were started, including chemical alterations and the addition of additives [4].

Zulhanafi et al. [5] explored that CuO has great anti wear and anti-friction performances. Talib et al. [6] study also study on the addition of AC nanoparticle in nonedible nanofluid for machining application. They found that, with the addition of AC nanoparticles, the coefficient of friction, wear scar diameter and surface roughness improve excellently. Therefore, modified jatropha oil mixed with two types of additives (Copper Oxide and Activated Carbon) was investigate in this study. The potential of modified jatropha nanofluids was estimated using machining performance in terms of cutting temperature and chip thickness.

2 Methodology

Orthogonal cutting was carried out with the orthogonal cutting parameters specified in Table 1 on an NC lathe machine (Alpha Harrison 400). The workpiece in this study was AISI 1045, a simple medium carbon steel. AISI 1045 is widely used in the engineering and manufacturing industries, and it is frequently used in modelling software [7]. As a cutting tool, a square form insert with the model number SPGN120308 was employed. The lubricant was supplied using the minimum quantity lubrication (MQL) approach. During the machining process, a thermal imager camera FLIR T640 was utilised to measure the highest cutting temperature by putting the camera in an axial direction. Chip thickness was measured with a micrometre (Mitutoyo IP 65). The average reading of the chip thickness was clarified after ten pieces of chips were taken to measure every machining parameter.

Table 1 Orthogonal cutting parameters

Description	Values
Cutting speed, *Vc* (m/min)	350
Feed rate, *fr* (mm/rev)	0.08
Width of cut, *w* (mm)	2
Axial cutting length (cm)	10
Cutting tool	Uncoated carbide
Type of metalworking fluids	- MJO + 0.01wt.% CuO - MJO + 0.025wt.% CuO - MJO + 0.05wt.% CuO - MJO + 0.01wt.% activated carbon - MJO + 0.025wt.% activated carbon - MJO + 0.05wt.%) activated carbon - Synthetic ester (SE)-reference oil

3 Result and Discussion

The graph in Fig. 1 reveals that MJO + Activated carbon (MJOa) has better machining performance compared to the MJO + CuO (MJOc) because MJOa has a low thermal expansion coefficient (3.6 × 10^{-5} °C – 1). MJOa2 (MJO + 0.025wt.% activated carbon) showed the best machining performance among MJOa in terms of cutting temperature, chip thickness and tool chip contact length. Among the MJOc, the best machining performance is MJOc2 (MJO + 0.025wt.% CuO) in terms of cutting temperature, chip thickness, and tool chip contact length. The results showed that the higher concentration tends to the increasing cutting temperature and chip thickness. Excessive among of additives increased the friction during machining process and the lubrication film could not be formed, thus result in reduction of the machining performance.

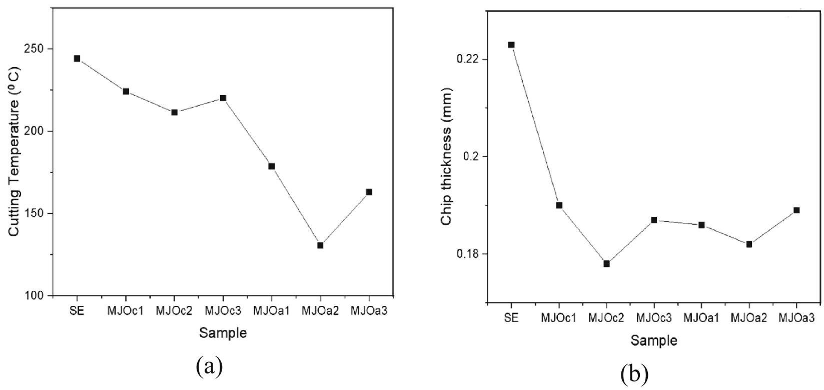

Fig. 1 (a) Cutting temperature (b) chip thickness

4 Conclusion

In conclusion, the overall best machining performance is MJOa2 (MJO + 0.025wt.% activated carbon) and it has the potential to be on the lubricant market with regard to environmental concerns and energy saving.

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