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Effect of paraffin oil with XGnP and Fe_2O_3 nanoparticles on tribological properties

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ABSTRACT

Recent studies have utilized different nanoparticle elements in oil added substances with base fluid, which improves their lubricating properties. In this study, the four-ball friction tester and viscosity nanofluid, which is prepared with the suspension iron oxide nanoparticles (Fe_2O_3) and xGnP (exfoliated nanographene) nanoparticles, in paraffin oil as base fluid. The viscosity and friction coefficient of lubricating properties of nanoparticles that was added at varying concentrations of 0.4% (1.6 g), 0.8% (3.2 g), and 1.2% (6.4 g) by weight of (Fe_2O_3) and xGnP with the size of less than 10 nm was added for 400 g of paraffin oil. The viscosity of nanolubricant at the temperature range (40 °C−100 °C) was increased at a percentage of 0.29%, 0.08% in both nanoparticles XGnP and Fe_2O_3. To measure the corrosion resistance and friction rate, a four-ball test is used nanolubricant was observed to influence these properties of paraffin oil for all concentration levels.

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1. Introduction

In the past two decades, the study on the utilization of nanoparticles for machining applications has increased more consideration [1]. Silicon carbide (SiC) is very desirable material due to its attractive mechanical, physical and chemical properties such as high hardness, high melting point, good electrical [2]. The SiC material benefit from both SiC and graphite for their hardening and self-lubricating properties, respectively [3]. Straight liquids, manufactured and semi-engineered liquids, solvent liquids, and vegetable-based cutting liquids (VBCFs) can be broadly defined kinds of metal cutting liquids (MCFs). There are many things that have negative effects on the environment, for instance, petrochemical cutting fluids [4]. To Increase the lifetime of contact interfaces to have a minimum rate of friction simultaneously to reduce the corrosion must be used lubricants. Several pure compounds have been used as antiwear and excessive pressure lubrication additives, according to the previous researches [5]. The process of energy consumption disruption of mechanical materials is friction and corrosion. To improve in an international industry, friction and corrosion must be the lowest value, which is accurate by the mechanical contact In additions, the use of lubricants to improve productivity and prolong the life of the machines [6]. Fine electrons, bio-supply, transport, and central air have been proposed as advanced heat transfer fluids because of their advantages in many applications. For example, jet nanomaterials have attracted incredible enthusiasm [7]. To decrease interfacial friction and wear a wide diversity of lubricants has been used. Numerous investigators worry about how to decrease friction and wear during the activity of apparatus and gear. The development of a defensive covering on the shearing surface nanoparticles of graphene (xGnP) layers can reduce the corrosion and decreased wear on sliding steel surfaces crediting [8]. Since the 1990s is regularly developing Utilization of vegetable oils in metal cutting tasks as a coolant/grease intention because of their high biodegradability, greasing up properties, nontoxic and ecological agreeableness [9]. Mineral oil-based coolants have been used as a cutting fluid in metal cutting operations for over generations [10]. To get knowledge and To develop superior composites for applications under the limit and blended circumstances into the tribological it is of essential enthusiast components of polymer-based materials presented to fluid mediums [11]. Most oils used in the mineral industries are divided into vegetable and industrial oils. One of the

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biolubricant properties that are usually considered is the viscosity. Furthermore, this type is the most important characteristic of a lubricant for evaluating the suitability of a lubricant. [12]. At 130 and 294 purposes of coconut oil to measure the viscosity and flash point separately. Canned vegetable oils played an important role because it has an important characteristic, including sesame oil, coconut oil, and others [13]. Tribological properties of nano and small scale with composites the mechanical to create antifriction materials delivered by expulsion under the states of dry contact, limit grease, and rough wear [14]. In dry sliding conditions in a three-temperature test device, the slip stroke is examined to observe the effects of operating temperature applied to the load [15]. Nevertheless, can see from some previous studies conducted on vegetable oil at room temperature Celsius around 30 °C; for instance, this study reported that nanoparticles are evaluated on a wide range of temperatures. Besides, the improved properties of the lubricant [16].

Consequently, this present study targets assessing the properties of metallic oil-paraffin gamma iron oxide (Fe_2O_3) and nanographene (xGnP) to investigate these two types of nanoparticles with paraffin by improve the viscosity and reduce the friction and (WSD) respectively.To engage a proper appreciation of temperature minor to enable a correct understanding of temperature behavior on a large scale at different levels of concentrations. Hence, to determine the optimum condition of machining tribology study in metal cutting is vitally significant progress. The performance two nanoparticles, as represented xGnP and (Fe_2O_3) will be concentrated through an experimental approach in terms of viscosity and friction behavior.

1.1. Preparation of nanoparticles

The two-advance technique for nanofluid readiness, as utilized. By Su et al. Peeled gamma iron oxide and nanographene particles of under 10 nm and paraffin oil are being used in the plan of the nanofluids at different fixation levels of 0.40, 0.80 and 1.20 wt% [17]. When mixing coconut oil with nano-particle at a rotation speed of 3200 rpm so that it is homogeneous for 40 min and is then adopted in the dispersion of silicon carbide nanoparticle particles. Because of their influence on the physical and thermal properties, nanoparticles are prepared at varying concentration levels for evaluation [16].

1.2. Viscosity of nanoparticles

The thickness of base fluids tends to decrease as the temperature increase as well as for nanofluids [18,19]. Viscosity plays an essential role in the lubrication process and is considered one of the standard critical factors for testing the right oil [20].The purpose of the experimental approach in this study is to extract the viscosity of paraffin oil as a base fluid compared with two types of nanoparticles XGnP (exfoliated nanographene) and Fe_2O_3 (iron oxide) with the liquid[21]. Viscosity was measured at different temperatures ranges between 40 °C and 100 °C for two different types of nanoparticles using a with a Cole-Parmer® rotational viscometers. The sample to be valued at 250 ml is heated in the cylinder casing and the unit is connected to the rheometer. So at least three experiments are taken at each test temperature with a consideration value.

1.3. Tribological properties of nanoparticles

Utilizing the ASTM D4172-94 technique to assess rubbing and wear by (four-ball test) at different concentrations of tribological conduct nanoparticles and paraffin oil according to the previous research [16]. Utilizing steel ball (AISI 52100) of breadth 12.7 mm and a hardness estimation of 62HRC are assessed by defensive characteristics and coefficient of friction of the lubricants. Take 10 ml of lubricant poured into three steel balls so which the top shot is fixed on the two balls so that all the balls are immersed in the oil being tested. The conditions of the reaction as far as rotational speed, burden, and temperature for this investigation 1200 rpm, 392 N and 75 °C individually. After testing, the mean (WSD) was measured using an optical microscope. Table 1 can be seen as the properties of paraffin oil.

1.4. Effect of iron oxide nanoparticle (Fe_2O_3) inclusion on the viscosity of paraffin oil

This study explores the use of the different quantity of Fe_2O_3 nanoparticles suspended in paraffin oil as base fluid, as shown in Fig. 1. The viscosity of nanofluid was slightly increased compared to paraffin oil. The thickness of nanofluid slightly increased when the percentage of nanoparticles was increased from 0.4% to 1.2%. Fluid with a higher concentration percentage of gamma iron oxide nanoparticles (Fe_2O_3) provides better lubricants. This was of the same trend reported by Refs. [22,23] when nanographene and Fe_2O_3 were used, respectively.The viscosity behavior of oil is shown in Fig. 1. It was observed that at 40 °C, both 0.4 wt% and 0.8 wt% concentrations indicated same effect while 1.2 wt% concentration reported marginal increase of viscosity. The impact of nanoparticle inclusion in the paraffin oil was observed at 0.8 wt% and 1.2 wt% with significant increase in the thickness of lubricant at 70 °C and 100 °C. About 30.65% and 27.7% enhance viscosity was achieved in compassion to the pure paraffin oil at 70 °C.

1.5. Effect of nanographene (XGnP) inclusion on the viscosity of paraffin oil

Fig. 2 shows that the different concentrations of XGnP nanoparticles suspended in paraffin oil as base fluid. The viscosity of

Table 1
Characteristics of paraffin oil.

Essential characteristics of paraffin	Basic features of paraffin oil
Kinematic viscosity at 40 °C	15.35 mm^2/s
Flashpoint	190 °C
Pour point	−15 °C
Colour	Colorless at +30 °C
Corrosion test (100 °C 3 h) grade	1

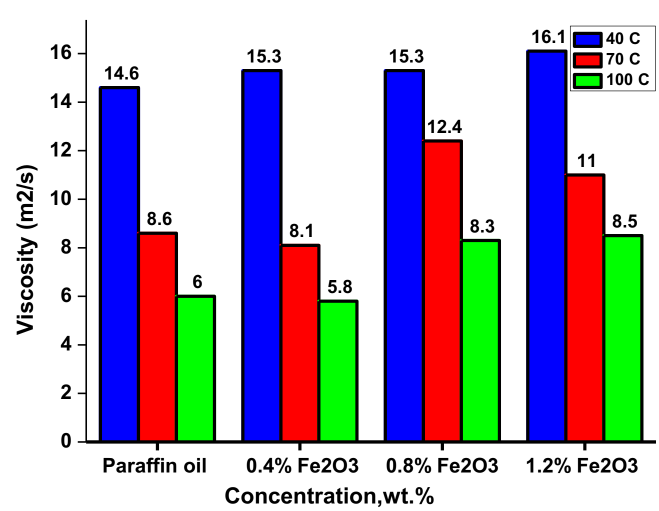

Fig. 1. Viscosity of paraffin oil and Fe_2O_3 nanofluids versus temperature.

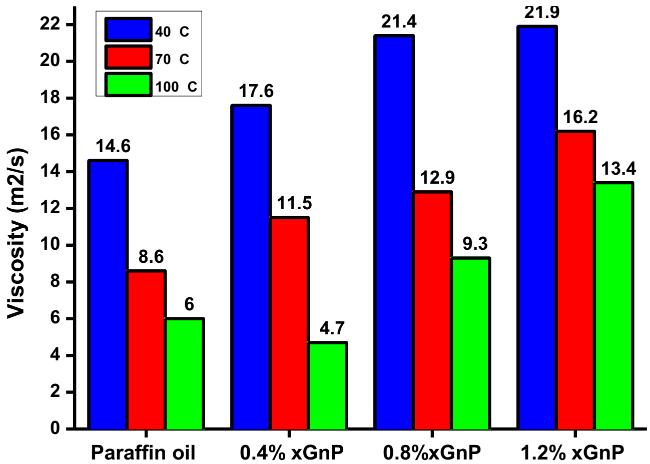

Fig. 2. Viscosity of paraffin oil and xGnP nanofluids versus temperature.

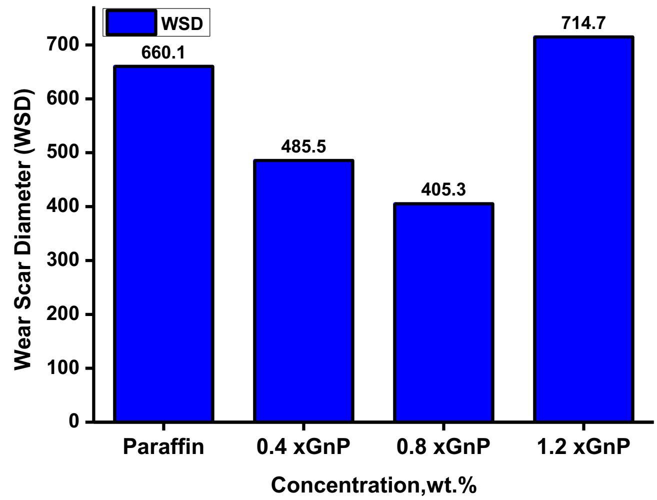

Fig. 4. Influence of Nanoparticles XGnP on the anti-wear properties.

paraffin oil and nanofluid tend to decrease as the temperature increase. Fig. 2 shows the viscosity behavior of paraffin lubricant with and without nanoparticles dispersion. The effect of xGnP nanoparticles inclusion was observed to increase the viscosity of Nano lubricant for all concentrations and temperature range considered except for 0.4 wt% at 100 °C when the viscosity paraffin poorly compared to the pure paraffin oil. At a temperature of 70 °C, all the considered concentrations of 0.4, 0.8, and 1.2 wt% inclusion indicates the more super performance of pure paraffin oil by 29.2%, 33.3, and 46.9%, respectively.

1.6. Influence of nanoparticle (Fe_2O_3) and XGnP on the anti-wear properties

From the four-ball tests, the (WSD) wear scar diameter decrease first and then increase with the addition of nanoparticles graphite (XGnP) and iron oxide (Fe_2O_3) at different concentration (0.4 wt %,0.8 wt%,1.2 wt%). As shown in Figs. 3 and 4, the best tribological (WSD) properties as a lubricant additive of Paraffin as a base fluid is the lowest (WSD) purports significant wear defensive characteristics. The result of the wear investigation reveals that the concentration of nanographene xGnp at 0.4 wt% was better to wear preventive properties. The features of both nanoparticles were assessed for shifting qualities, and all levels of concentration

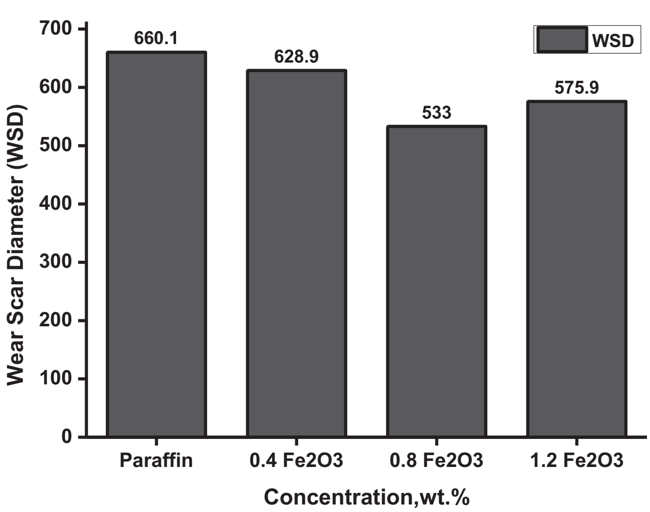

Fig. 3. Influence of Nanoparticle (Fe_2O_3) and on the anti-wear properties.

demonstrated better execution over the unadulterated base oil. All levels of frequencies, the wear preventive property improved significantly over the pure paraffin oil. Fig. 3 shown the WSD under lubrication with the paraffin base oil and the concentration paraffin dispersed with gamma iron oxide. It was observed that addition of paraffin up to 0.8 wt% concentration indicated reduction of wear while the 1.2 wt% level shown slightly increase in wear but still lower when compared to 0.4 wt% concentration and pure paraffin oil.

The behavior of varying weight concentration of lubricant under condition was shown in Fig. 4. The nanolubricant with 0.4 wt% and 0.8 wt% indicates significant reeducation in wear, while the 1.2 wt% shows poor performance at the WSD worse than lubrication with pure oil. These could be due to agglomeration due to the higher concentration of particles. About the absolute oil lubrication, about 24.45% and 38.60 wear scare diameter (WSD) reduction achieved with the addition of 0.4 wt% and 0.8 wt% respectively.

2. Conclusions

The present work demonstrates the XGnP, and Fe_2O_3 nanoparticles (0.4 wt%, 0.8 wt%, 1.2 wt%) is added in the paraffin lubricants as base fluid to analyze the tribological performance and to see the effect of viscosity. Four-ball tribo-tester is used to analyze the lubricant performance at these concentrations. The following conclusions have been drawn from the present study:

Increasing temperature leads to a decrease in the viscosity of the lubricant. The effect of temperature on reduction in thickness with base oil while growing nanoparticles gives better coherence In comparison with paraffin oil in the temperature range (40 °C–100 °C), increasing viscosity at the percentage of 0.29%, 0.08% was observed in both nanoparticles XGnP and Fe_2O_3. Besides, XGnP has been showed a suitable thickness compare with Fe_2O_3. Wear scar diameter was higher at paraffin oil without nanoparticle additives, and then friction decreases when increase in the concentration of nanoparticles.When level of strength nanoparticles increased, the friction coefficient and wear scar diameter significantly reduce till 0.8 wt% for both nanoparticles. Concerning the pure oil lubrication, about 24.45% and 38.60 wear scare diameter (WSD) reduction achieved with addition of 0.4 wt% and 0.8 wt% respectively. When mixed by paraffin oil the ability of higher anti-wear doesn't appear, while when increasing the nanoparticles at 1.2 wt% that have been raised the friction and wear scar diameter. Due to addition of XGnP nanoparticles in the base fluid-like paraffin oil, on four ball tester that leads to slightly minimize the WSD. Moreover, by increasing the temperature continuously, the viscosity of lubricant was decreased which leads to a reduction in the friction.

CRediT authorship contribution statement

Faraj Saeid Adrees Majeed: Conceptualization, Data curation, Funding acquisition, Methodology, Writing - review & editing. **Nordin Bin Mohd Yusof:** Conceptualization, Writing - review & editing. **Mohd Azlan Suhaimi:** Funding acquisition, Writing - review & editing. **Nagwa Mejid Elsiti:** Methodology. **Siti Norbiha bt A. Aziz:** Methodology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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