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Copper-oxide brake nanofluid manufactured using arc-submerged nanoparticle synthesis system

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Abstract

This study examines the characteristics of copper-oxide brake nanofluid (CBN) manufactured using the arc-submerged nanoparticle synthesis system (ASNSS). Brake fluids containing copper nanoparticles are developed by melting bulk metal used as the electrode which is submerged in dielectric liquid. Copper is vaporized in brake fluid DOT3, which is used as an insulting liquid, and then rapidly quenched thus nucleating and forming nanocrystalline copper powders. The CBN thus obtained shows higher boiling temperature, higher viscosity and higher conductivity, which are affected by the synthesis parameters such as cooling liquid temperature and processing current. This study reveals that a home made machine can produce the CBN which higher boiling point to reduce the occurrence of vapor-lock, higher viscosity and higher conductivity thus showing superior performance of copper brake nanofluid.

Keywords: Copper-oxide brake nanofluid (CBN); Arc-submerged nanoparticle synthesis system (ASNSS); DOT3; Nanocrystalline

1. Introduction

Much research and development for new nanoparticle synthesis has been proposed and implemented in the past decades. The first nanofluid patent [4] claimed heat conductivity to be 1.6 times over that of water. This shows nanofluid to be a revolutionary product as a heat transmission or lubrication agent. ASNSS is innovative because the raw materials are submerged in the dielectric liquid during the process within a vacuum-operating environment and the vaporized metals are condensed in dielectric liquid. Nanoparticles can be successfully prepared and uniformly dispersed in DOT3 brake liquid.

The suspension with well-dispersed nanoparticles in copper brake nanofluid (CBN) can be used directly in various applications. In the processing, the key parameters influencing the nucleation of nanoparticles are the pressure and temperature of the operating vacuum chamber. The electrical energy heats the brake fluid in the vacuum chamber at a low pressure. CBN yields such characteristics as higher boiling point, higher viscosity and higher conductivity in a stabilized state. This work is intended as a preliminary study on developing CBN using the arc spray nanoparticle synthesis system (ASNSS) [1–3] based on a rudimentary braking theory of converting kinetic energy into heat energy. The heat energy is absorbed through braking parts and the braking command dispersion is mainly achieved through the braking bearing pads. Braking drum or friction between the disks creates the blocking effect. CBN serves to surpass the boiling point and conductivity to reduce the occurrence of vapor-lock which, accordingly, increases driving safety.

2. Experimental details

The arc-submerged nanoparticle synthesis system (ASNSS) is shown in Fig. 1. A pure copper bar, used as the electrode is melted and vaporized in dielectric liquid (DOT3 brake fluids). The Cu bulk bar, used as an electrode is submerged in the brake fluids. After setting the proper parameters of the process, electrical energy is supplied to the electrode. The parameter control system is comprised of a processing parameter system, pressure balance system and a temperature control system. Also the monitoring system ensures that the entire synthesizing process has been smooth. After the copper rod's reaching a vaporized state and coagulating into the brake fluid, the brake fluid containing nanoparticles is retrieved. Observation by a transmission electron microscope (TEM) is used to measure the particle dimensions and state of distribution.

X-ray diffraction (MAC-MXP18, wavelength: 1.54056 nm) is used to obtain the pattern of nanoparticles. Any inconsistent findings would require going back to the processing parameter system to adjust the processing parameters until

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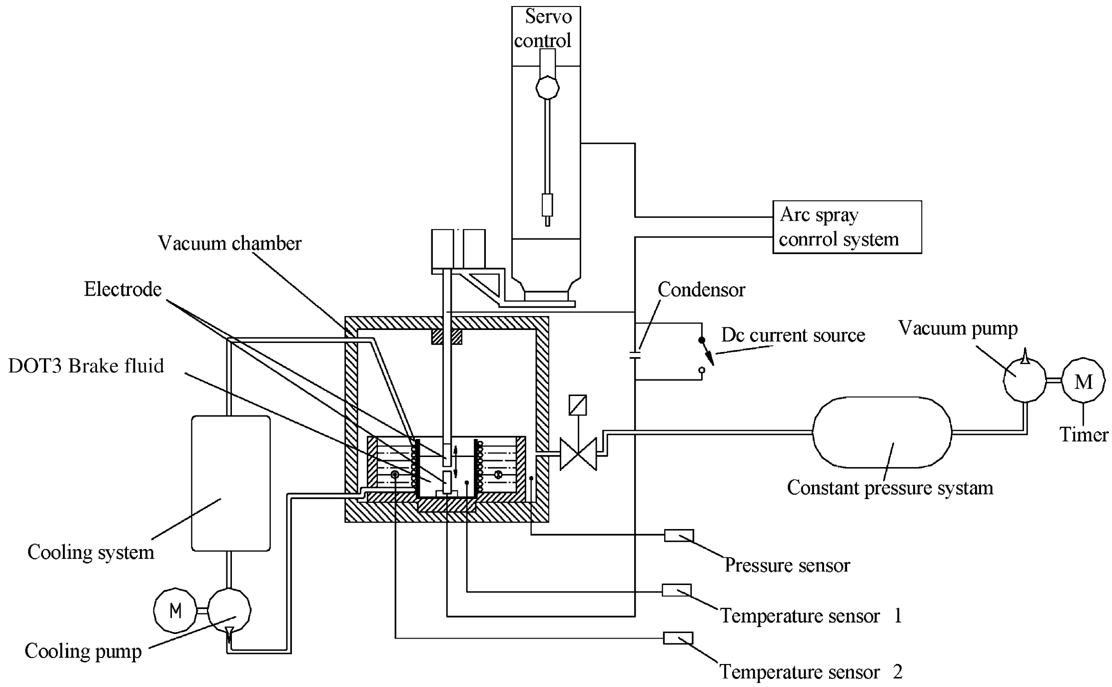

Fig. 1. The arc-submerged nanoparticle synthesis system (ASNSS).

they reach the specified criteria. When they fall within the specified criteria the specimen is regarded as a stabilized nanofluid. The Cannon-Fenske Routine Viscometer and the transient hot-wire method are also employed to measure viscosity and thermal conductivity (Decagon KD2 measure meter).

3. Results and discussion

Fig. 2 shows the XRD pattern of CuO nanoparticles prepared by ASNSS. Because oxygen exists in brake fluid, the nanoparticles are easily oxidized.

An operating chamber with a low and stable vacuum pressure can mass produce the CBN. In Fig. 3, the TEM image shows the small particle size (approximately 30 nm in width for copper-oxide particles).

Fig. 4 shows how temperature fluctuations come to affect the viscosity of CBN and DOT3 brake fluid. When the liquid is subjected to rising temperature, the liquid viscosity drops. The viscosity rating of nanofluid with copper-oxide nanoparticles tends to be higher than DOT3 liquid. The higher viscosity of CBN is attributed to the copper-oxide nanoparticles. Nanofluid viscosity is derived from the liquid plus nanoparticles model as in Eq. (1),

$$\frac{hN_{\mathrm{b}}}{V_{\mathrm{m}}}\exp\left(\frac{E}{RT}\right)+5\left(\frac{MRT}{\pi}\right)^{1/2}\left(\frac{1}{16N_{\mathrm{A}}\sigma^{2}}\right) \qquad (1)$$

in which, h is Planck constant, N_{b} the molecule mass, E the molecular kinetic energy, V_{m} the volume of molecule, M mass,

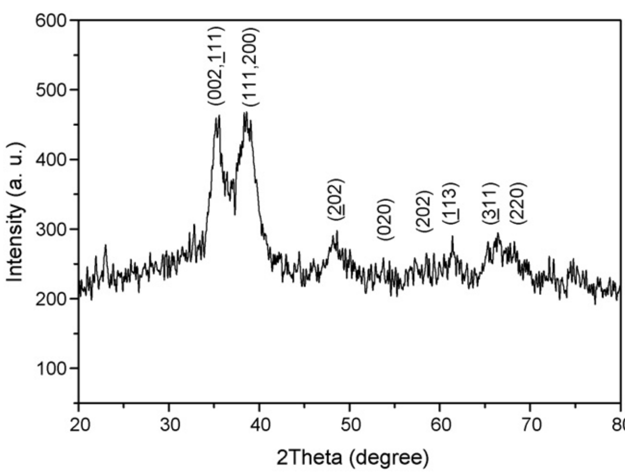

Fig. 2. The XRD pattern of CuO nanoparticles prepared by ASNSS.

Fig. 3. TEM image of nanoparticles (approximately 90 nm in length and 30 nm in width).

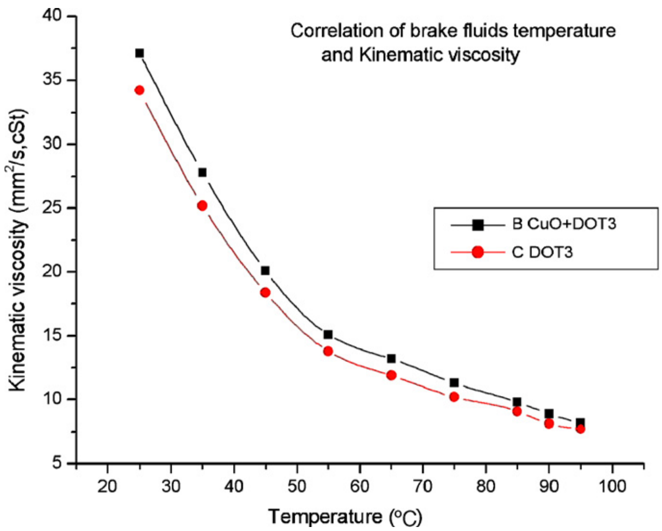

Fig. 4. Brake fluid's temperature and viscosity fluctuations.

Table 1
Brake fluid's boiling point and conductivity

	DOT3 (shell brake fluid)	CBN (CuO + DOT3), 2 wt%
Boiling point	270 °C	278 °C
Conductivity (25 °C)	0.03 W/m°C	0.05 W/m°C

N_A the Avogadro's number, R universal gas constant and σ is the molecule's radius [5,6].

With the conductivity measure meter, Decagon KD2, the specimen was measured 20 times, each time lasting 10 s. The measurement time should be kept short to avoid convection which may undermine the measurement accuracy. As seen in Table 1, the boiling point of CBN would increase approximately 8 °C and the heat conductivity of CBN is 1.6 times over the yield of DOT3 brake fluid which goes from 0.03 to 0.05 W/m °C, thus indicating nanofluid to be a revolutionary product as a heat transmission or lubrication agent.

4. Conclusion

Copper-oxide nanofluid can be prepared when applying pressure and temperature control systems in home made ASNSS. There are three good characteristics in CBN manufactured by ASNSS. First, the boiling point of CBN increases approximately 8 °C. Performance of brake oil demands a higher boiling point, because brake oil is easily affected by the heat generated from braking. Brake oil with a lower boiling point may easily boil and followed by an airlock which will result in a brake malfunction. Secondly, the viscosity of CBN is consistently higher than that of DOT3 (traditional) brake fluid. Finally, CBN conductivity is 1.6 times that of DOT3 brake fluid which is from 0.03 to 0.05 W/m°C, thus indicating that nanofluid is a revolutionary product for heat transmission or lubrication agent.

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