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Effects of Nano Copper Additive on Thermal Conductivity of Magnetorheological Fluid at Different Environment Temperature

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Abstract. Low thermal conductivity of magnetorheological (MR) fluid limits its potential to be applied in high temperature environment. Recently, enhancing thermal conductivity of similar fluids through addition of nano copper has attracted to address the problem. This paper presents the effects of nano copper addition on thermal conductivity properties of MR fluid at different environment temperatures. The nano copper added MR fluid samples were synthesized with carbonyl iron powder in hydraulic oil. The samples were then stabilized with addition of fumed silica and were homogenized using ultrasonic bath. Thermal conductivity of the samples and references material was measured using thermal property analyser. The environment temperature of the samples was controlled by waterbath incubation method. The results showed that enhancement of thermal conductivity with the presence of copper nanoparticles was higher at 40 vol% of CIP compared to 20 vol% of CIP and a slight variation in thermal conductivity of MR fluid was observed in environment temperatures of 30–70°C. This finding leads to development of new class of magnetorheological fluid with enhanced thermal properties.

Introduction

Magnetorheological (MR) fluids possess phase change behaviour where rheological properties of the material are alterable with magnetic field [1]. Due to this advantage, MR fluid is beneficial to be applied in active and semi-active devices [2]. However, at high temperature environment, instability behaviour of shear thinning and decreasing shear stress is significant. Improving thermal conductivity of MR fluid may dissipate heat at higher rate and eventually overcome those problems.

Analogous to materials like ferrofluids, thermal conductivity of MR fluid can be increased by either increasing particle volume fraction of magnetic particles [3, 4] or adding nano-metal particle [5, 6]. Smaller particles size resulted in increment of thermal conductivity as much as 5% in Al2O3 nanofluid with 150 nm particles size. Whereas, in nanofluid containing 47 nm particles size, 10% enhancement of thermal conductivity was recorded [7]. Furthermore, base fluid properties are significant to set minimum value of thermal conductivity. In a study of base fluids effect on thermal conductivity of nanofluid containing graphene oxide nanosheets, mineral oil based fluid was found to enhance the thermal conductivity by ratio of 76.8% compared to propylene glycol at 62.3% and distilled water at 30.2% [8]. Enhancement of thermal conductivity was also reported in metals and metal-oxide based nanofluids where aluminium and alumina additive enhanced thermal conductivity by 27% and 17%, respectively [8]. Copper nanoparticle has been reported as an additive in nanofluids with high melting point temperature, non-magnetic and high thermal conductivity [9]. In this study, the effect of copper nanoparticle additive in MR fluids was measured. MR fluid samples were measured at different CIP, base fluid, and copper nanoparticles percentages.