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Investigation of thermal conductivity and viscosity of Al_2O_3/water–ethylene glycol mixture nanocoolant for cooling channel of hot-press forming die application☆

S.K. Lim [a], W.H. Azmi [b,c,*], A.R. Yusoff [a,c]

[a] Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
[b] Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
[c] Automotive Engineering Centre, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia

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ABSTRACT

Hot-press forming process is widely used to produce lightweight chassis in automotive industries. The hot-press forming process currently uses water as coolant to quench boron steels in a closed die with a cooling channel. However, to enhance performance of hot-press forming die, the fluid with better thermal properties will be used instead of normal water. This study dispersed Al_2O_3 nanoparticles with an average diameter of 13 nm in three volume percentages base ratios of water (W) to ethylene glycol (EG) (i.e. 60:40, 50:50, and 40:60) by two-step preparation. The two main parameters in cooling rate performance are thermal conductivity and viscosity. The nanocoolant of Al_2O_3/water–ethylene glycol mixture is prepared for the volume concentration range of 0.2 to 1.0%. The thermal conductivity and viscosity are then measured at temperature range of 15 to 55 °C. The highest enhancement of thermal conductivity was observed to be 10% higher than base fluid for 1.0% volume concentration at 55 °C in 60:40 (W/EG). However, the highest enhancement of viscosity was measured to be 39% for 1.0% volume concentration in 40:60 (W/EG) at 25 °C. The convective heat transfer coefficient of 1.0% concentration in 60:40 (W:EG) at 25 °C is enhanced by 25.4% better than that of 50:50 and 40:60 (W:EG) base fluid. Therefore, this study recommends the use of Al_2O_3 in 60:40 (W:EG) mixture with volume concentration of less than 1.0% for application in cooling channel of hot-press forming die. Nanocoolant as cooling agent with higher heat transfer coefficient compared to the base fluid can reduce the cycle time and increase the productivity of hot-press forming process.