INVESTIGATION OF FORCED CONVECTION HEAT TRANSFER FOR Al_2O_3 NANOFLUIDS IN DIFFERENT BASE MIXTURE

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ABSTRACT

In the thermal engineering application, suspension of nanoparticles in conventional fluid has positive potential in enhancing the convective heat transfer performance. Nanofluids are developed to meet the challenges of improving the efficiency of the cooling system subsequently minimizing the energy waste. This thesis aims to investigate the forced convection heat transfer for Al_2O_3 nanofluids in different ratios of water (W) and ethylene glycol (EG) base mixture at different working temperatures. The Al_2O_3 nanofluids are formulated using the two-step method for three different base mixture with volume ratio of 60:40, 50:50 and 40:60 (W:EG). The volume concentration varies between 0.2 to 1.0 %. The properties measurement of thermal conductivity and viscosity of nanofluids are conducted using scientific laboratory equipment. The forced convection experiments are conducted using modified convection experimental setup under constant heat flux conditions for operating temperatures of 30, 50 and 70 °C at Reynolds numbers from 3,000 to 25,000. The enhancement of viscosity for nanofluids decrease with the increment percentage of ethylene glycol. Meanwhile, thermal conductivity have positive enhancement as the percentage of ethylene glycol increases. The forced convection results indicate that with increased volume concentrations, the heat transfer coefficient is enhanced compared to its base fluid at all designated temperatures. The enhancement of nanofluids is observed to be improved further with the increase of temperature. The effect of different base mixture ratios display that nanofluids in 60:40 (W:EG) base mixture have the highest percentage of performance with 24.6 % enhancement at 1.0 % volume concentration and temperature of 70 °C. The increment of volume concentration for nanofluids shows a slight rise in friction factor and pressure drop. As a conclusion, the thermo-physical properties and the forced convection heat transfer for nanofluids in various base mixture shows that volume concentrations, base fluid, and temperature influences the enhancement of heat transfer. The Al_2O_3 nanofluids with 1.0 % volume concentration in 60:40 (W:EG) base mixture are recommended for various applications in heat transfer.

ABSTRAK

Dalam aplikasi kejuruteraan terma, pengapungan zarah bersaiz nano di dalam cecair konvensional mempunyai potensi yang positif bagi meningkatkan prestasi pemindahan haba secara olakan. Bendalir nano telah dibangunkan bagi menghadapi cabaran penambahbaikan kecekapan sistem penyejukan seterusnya meminimumkan pembaziran tenaga. Tesis ini bertujuan untuk mengkaji pemindahan haba olakan secara paksaan menggunakan bendalir nano Al_2O_3 dalam nisbah berlainan bagi campuran air (W) dan etilena glikol (EG) pada suhu operasi yang berbeza. Bendalir nano Al_2O_3 telah diformulasikan menggunakan kaedah dua-langkah bagi tiga asas campuran yang berbeza mengikut nisbah isipadu iaitu 60:40, 50:50 dan 40:60 (W:EG). Kepekatan isipadu bermula 0.2 sehingga 1.0 %. Pengukuran sifat kekonduksian terma dan kelikatan bendalir nano dijalankan mengunakan peralatan saintifik makmal. Ujikaji olakan secara paksaan dijalankan menggunakan peralatan ujikaji olakan yang telah diubah suai dengan fluks haba yang tetap dan suhu operasi 30, 50 dan 70 ^oC pada nombor Reynolds antara 3,000 sehingga 25,000. Peningkatan kelikatan bendalir nano menurun dengan kenaikan peratusan etilena glikol. Manakala, sifat kekonduksian terma mengalami peningkatan dengan penambahan peratusan etilena glikol. Hasil kajian olakan secara paksaan menunjukkan dengan peningkatan kepekatan isipadu, pekali pemindahan haba meningkat berbanding bendalir asas pada semua suhu. Prestasi bendalir nano semakin bertambah baik dengan peningkatan suhu operasi. Pada nisbah asas campuran berbeza menunjukkan bendalir nano didalam nisbah campuran 60:40 mempunyai prestasi yang paling tinggi sebanyak 24.6 % pada kepekatan 1.0 % dan suhu 70 ^oC. Penambahan kepekatan isipadu bendalir nano memberi sedikit peningkatan kepada pekali geseran dan penurunan tekanan. Sebagai kesimpulan, sifat terma-fizikal dan pemindahan haba olakan secara paksaan bagi bendalir nano dalam nisbah asas campuran yang berbeza menunjukkan bahawa kepekatan isipadu, nisbah asas campuran dan suhu mempengaruhi peningkatan pemindahan haba. Bendalir nano Al_2O_3 dengan kepekatan isipadu 1.0 % di dalam asas campuran 60:40 (W:EG) adalah dicadangkan untuk aplikasi yang berkonsepkan pemindahan haba.