DEVELOPMENT OF WATER-ETHYLENE GLYCOL BASED GRAPHENE NANOPLATELETS/CELLULOSE NANOCRYSTAL HYBRID NANOFLUID AS RADIATOR COOLANTS AND ITS PERFORMANCE EVALUATION

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis, and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRACT

Traditional thermal fluids are incapable of absorbing the significant amount of heat generated by high performance engines. Greater engine performance requires extra consumed fuel, exposing combustion chambers to excessive heat. An automotive cooling system is designed to maintain the engine temperature at optimal levels. With the rapid growth of technology in the automotive industry, there is a need to increase the performance of conventional cooling systems to improve engine performance. Radiator plays a prominent role in increasing the performance of the cooling system. However, there is a demand for higher thermal properties fluid as the transport medium because of the insufficient thermal performance of traditional fluids. Hybrid nanofluids are exceptional heat transfer liquids due to their superior thermal conductivity. An experimental approach to prepare, characterize and stabilize the hybrid nanoparticles (Graphene nanoplatelets and Cellulose nanocrystals-50:50) in the base fluid (Ethylene Glycol-Water-60:40)) and to analyze the thermo-physical properties of the newly developed hybrid nanofluids and this is used as a coolant in automobile radiators. Combining with the coupling effect of two nanomaterials, the prepared hybrid nanofluids confirmed the proper dispersion stability by Zeta potential and UV absorption analysis and also enhanced the thermal conductivity with the increase in the volume concentration from 0.01%-0.2%. The maximum enhancement for thermal conductivity was around 27% attained at 0.2% hybrid nanofluid. With the increase in the particle loading, the viscosity increased but declined with the temperature by 21%. Moreover, the specific heat is decreased with the increment of hybrid nanofluid concentration. The results from the statistical analysis showed 0.2% GNP/CNC hybrid nanofluid as the optimum concentration for radiator application. The experimental results at different flow rates for hybrid nanofluid (0.2% volume concentration) presented a 41.44% improvement for convective heat transfer coefficient as a result of improved thermal conductivity and surface area and 12.34% pressure drop with respect to base fluid, with an increased density and viscosity the Reynolds number increased with the flow rate and obtained value is 3863.55. With the particle loading, the physical characteristics influenced Nusselt number enhancement with 26.77% for the proposed hybrid nanofluid at 7.2 LPM. Further, the size reduction analysis from computational modeling recommended the reduced dimensions for the flat radiator tube (major diameter-0.016m and length-0.24m) for increased heat transfer coefficient at decreased volume concentration (0.01% GNP/CNC). These outcomes show the overall thermal improvement of the radiator cooling system, which can reduce the dimensions (size and weight) of the radiator by the application of a novel hybrid nanofluid. Novel hybrid graphene nanoplatelets/ cellulose nanocrystal-based hybrid nanofluids performed better in automobile applications and are recommended for heat transfer enhancement in automotive industry.

ABSTRAK

Sistem penyejukan Automotif direka untuk mengekalkan suhu enjin pada tahap optimum. Dengan pertumbuhan teknologi yang pesat dalam industri automotif terdapat keperluan untuk meningkatkan prestasi sistem penyejukan konvensional untuk meningkatkan prestasi enjin. Radiator memainkan peranan penting dalam meningkatkan prestasi sistem penyejukan. Walau bagaimanapun, terdapat permintaan tinggi untuk cecair sifat terma yang lebih tinggi sebagai medium pengangkutan. Masa depan cecair nano hibrid dalam bidang pemindahan haba adalah agak menguntungkan. Salah satu komponen utama untuk kajian yang meluas ialah mengkaji proses untuk menambah baik ciri termofizik dan potensi aplikasi cecair nano hibrid. Oleh itu, pendekatan eksperimen untuk mengkaji prestasi pemindahan haba yang lebih baik dan taburan sifat termofizik bagi nanoplatelet grafena berasaskan etilena glikol-air dan cecair nanokristal selulosa (GNP/CNC) hibrid telah digunakan sebagai penyejuk didalam radiator kereta dalam penyelidikan ini. Gabungan antara kesan gandingan dua bahan nano, cecair nano hibrid yang disediakan mengesahkan kestabilan serakan yang betul oleh potensi Zeta & analisis penyerapan UV, juga telah meningkatkan kekonduksian terma dengan peningkatan kepekatan isipadu daripada 0.01% -0.2%. Peningkatan maksimum untuk kekonduksian terma didapati pada 0.2% cecair nano hibrid dengan 27% mencapai kelakuan bendalir Newtonian. Dengan peningkatan dalam pemuatan zarah, kelikatan meningkat tetapi penurunan suhu terjadi sebanyak 21%. Selain itu, haba yang spesifik telah berkurang dengan peningkatan kepekatan cecair nano hibrid. Keputusan daripada analisis statistik menunjukkan bahawa 0.2% GNP/CNC hibrid nanofluid adalah kepekatan yang optimum untuk aplikasi radiator. Hasil percubaan dijalankan pada kadar aliran berbeza untuk cecair nano hibrid (0.2% kepekatan isipadu) menunjukkan peningkatan 41.44% untuk pekali pemindahan haba perolakan hasil daripada kekonduksian haba & luas permukaan yang lebih baik, dan 12.34% penurunan tekanan berlaku dengan cecair asas (EG- W; 60: 40), dengan peningkatan ketumpatan & kelikatan nombor Reynolds meningkat dengan kadar aliran & memperoleh nilai 3863.55. Dengan pemuatan zarah, ciri fizikal telah mempengaruhi peningkatan nombor Nusselt sebanyak 26.77% untuk cecair nano hibrid yang dicadangkan pada 7.2 LPM. Selanjutnya, analisis pengurangan saiz daripada pemodelan pengiraan mengesyorkan dimensi yang dikurangkan untuk tiub rata radiator (diameter-0.016m & panjang utama/kecil-0.24m) untuk meningkatkan pekali pemindahan haba pada kepekatan isipadu yang berkurangan (0.01% GNP/CNC). Dapatan kajian ini menunjukkan peningkatan terma keseluruhan sistem penyejukan radiator dengan penggunaan cecair nano hibrid baru.

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