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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 Master of Science.

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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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SIMULATION AND EXPERIMENTAL ANALYSIS ON AUTOMOTIVE RADIATOR USING ORGANIC NANOCELLULOSE

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ABSTRAK

Semua haba berlebihan yang diperoleh dalam enjin pembakaran dalaman dikeluarkan oleh sistem penyejukan automotif untuk mengelakkan berlaku terlalu panas. Selanjutnya, tinjauan literatur menunjukkan bahawa peningkatan pada sirip dan saluran mikro di radiator sudah mencapai hadnya. Selain itu, telah diketahui bahawa cecair pengangkutan termal konvensional mempunyai sifat termofizik yang rendah dan mengakibatkan pelesapan haba yang buruk dari mesin. Permintaan cecair pengangkutan termal dengan sifat termofizik tinggi semakin meningkat kerana mampu meningkatkan prestasi pemindahan haba. Selain itu, setelah menggunakan bendalir pengangkutan termal yang diperbaiki, ukuran radiator dapat diminimalkan yang juga dapat menurunkan berat kenderaan. Lebih-lebih lagi, ia membantu meningkatkan prestasi enjin kenderaan apa pun. Beberapa dekad yang lalu, nanofluid diteliti secara meluas untuk digunakan dalam aplikasi pengangkutan haba. Nanofluid disediakan dengan menyebarkan bahan berskala nano ke dalam bendalir asas yang meningkatkan sifat termofisik bendalir. Dalam penyelidikan ini, zat nano yang digunakan adalah nanoselulosa yang telah diekstrak dari tanaman Western Hemlock pada kepekatan berat 8.0%, untuk digunakan sebagai cairan pengangkutan termal baru dalam radiator. Bahan nano tersebar ke dalam campuran air suling etilena glikol pada nisbah isipadu masing-masing 40:60. Prestasi pemindahan haba campuran nanofluid dan etilena glikol-air konvensional dibandingkan di rig ujian radiator buatan. Nanofluid disediakan dengan menggunakan kaedah penyediaan dua langkah. Kestabilan nanofluid dinilai melalui kaedah kualitatif dan kuantitatif. Hasil kestabilan membuktikan bahawa nanofluid dapat stabil selama lebih dari sebulan. Pengukuran sifat termofizik untuk nanofluid diukur untuk kepekatan isipadu 0.5%, pada julat suhu dari 30 oC hingga 80 oC. Analisis dari alat statistik menunjukkan bahawa kepekatan isipadu 0,5% memiliki sifat termofisik yang dioptimumkan dan telah digunakan sebagai nanofluid (cecair untuk pengangkutan termal) dalam radiator mana pun. Eksperimen ini dijalankan dalam dua keadaan yang berbeza: tanpa pengaruh kipas draf dan dengan pengaruh kipas draf. Hasil eksperimen menunjukkan bahawa pekali pemindahan haba eksperimen, pemindahan haba konvektif, nombor Reynolds, nombor Nusselt mempunyai hubungan berkadar dengan kadar aliran volumetrik. Sementara itu, faktor geseran mempunyai hubungan songsang dengan kadar aliran volumetrik. Tanpa pengaruh kipas, peningkatan pemindahan haba konvektif maksimum yang dicatatkan adalah 66.85% dan dengan pengaruh kipas, ia berada pada tahap 55.27%. Oleh itu, nanofluid dapat menghilangkan haba dengan cekap dari mana-mana sistem penyejukan automotif. Sebaliknya, peningkatan pemindahan haba maksimum yang melibatkan nisbah pemindahan haba konvektif ke pemindahan haba konduktif di radiator adalah 39.75% tanpa pengaruh keadaan kipas draf dan 43.24% dengan pengaruh keadaan kipas. Selain itu, faktor prestasi terma dan hidraulik maksimum tanpa dan dengan pengaruh kipas masing-masing adalah 2.15 dan 2.28. Oleh itu, nanofluid berasaskan nanoselulosa sesuai untuk aplikasi penyejukan automotif kerana ia mempunyai prestasi pemindahan haba yang lebih baik daripada cecair pengangkutan termal konvensional.

ABSTRACT

All the excessive heat obtained in an internal combustion engine is removed by the automotive cooling system to avoid any overheating. Furthermore, a literature survey showed that improvement on the fins and microchannel in the radiator already reached its limitation. Besides that, it has been known that the conventional thermal transport fluid has a low thermophysical property and results in poor heat dissipation from the engine. Demand for thermal transport fluid with high thermophysical property is increasing as it is able to enhance heat transfer performance. In addition, after using the improved thermal transport fluid, the size of the radiator can be minimised which also reduces the weight of the vehicle. Moreover, it helps to improve the engine performance of any vehicle. A few decades ago, nanofluid was widely researched to be used in heat transport applications. Nanofluid is prepared by dispersing nano-scaled materials into a base fluid which enhances the thermophysical property of the fluid. In this research, the nanosubstance used was nanocellulose that had been extracted from a Western Hemlock plant at a weight concentration of 8.0%, to be used as a novel thermal transport fluid in the radiator. The nanosubstance is dispersed into the ethylene glycol-distilled water mixture at a volume ratio of the 40:60, respectively. The heat transfer performance of the nanofluid and conventional ethylene glycol-water mixture is compared in a fabricated radiator test rig.Then, the experiment was conducted to validate with experiment of a radiator with nanofluid dispersed in Ethylene Glycol and water at different ratios. The nanofluid is prepared by using a two-step preparation method. The stability of nanofluid is evaluated through qualitative and quantitative method. The stability results proved that nanofluid can be stable for more than a month. The thermophysical property measurement for nanofluid is measured for volume concentration of 0.5%, at a temperature range from 30 oC to 80 oC. Analysis from a statistical tool showed that volume concentration of 0.5% has an optimised thermophysical property and it had been used as nanofluid (thermal transport fluid) in any radiator. An experiment for heat transfer performance of nanofluid and conventional thermal transport fluid was conducted in the automotive radiator test rig. The experiment was conducted under two different circumstances: without the influence of draft fan and with the influence of draft fan. The experiment results showed that experimental heat transfer coefficient, convective heat transfer, Reynolds number, Nusselt number had a proportional relation to the volumetric flow rate. Meanwhile, friction factor had an inverse relation to the volumetric flow rate. Without the influence of fan, the maximum convective heat transfer enhancement recorded was 66.85% and with the influence of fan, it was at 55.27%. Thus, the nanofluid was able to remove heat efficiently from any automotive cooling system. On the other hand, maximum heat transfer enhancement involving the ratio of convective heat transfer to conductive heat transfer in radiator is 39.75% without the influence of draft fan circumstance and 43.24% with the influence of fan circumstance. Besides that, maximum thermal and hydraulic performance factor without and with the influence of fan is 2.15 and 2.28, respectively. Thus, nanocellulose based nanofluid is suitable for automotive cooling application since it has a better heat transfer performance than conventional thermal transport fluid.

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