PERFORMANCE ENHANCEMENT OF RESIDENTIAL AIR CONDITIONING SYSTEM USING FAl_2O_3 AND TiO_2-POLYOLESTER NANOLUBRICANT

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DOCTOR OF PHILOSOPHY

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SUPERVISOR'S DECLARATION

We hereby declare that We have checked this thesis/project and in our opinion, this thesis/project 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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ABSTRAK

Sistem Penyaman Udara Kediaman (RAC) memainkan peranan penting untuk keselesaan semua orang di rumah dan pejabat. Satu penyelidikan telah dilakukan ini didorong oleh keinginan untuk mengurangkan kesan pemanasan global yang disebabkan oleh sistem RAC dan meningkatkan pekali prestasi (COP) dan penjimatan tenaga. Kajian ini mencadangkan penggantian poliolester (POE) sebagai pelincir konvensional menggunakan pelincir nano FAl_2O_3-POE dan TiO_2-POE untuk prestasi dan kecekapan yang lebih baik. Seterus ia dapat menggantikan medium penyejuk sedia ada R410a menggunakan R32, yang mana mempunyai Potensi Pemanasan Global (GWP) yang lebih rendah. Objektif kajian ini adalah (i) untuk mencirikan sifat termofizik pelincir nano FAl_2O_3-POE dan TiO_2-POE untuk aplikasi dalam sistem RAC yang menggunakan medium dengan penyejuk R410a dan R32, dan (ii) untuk menilai pelincir nano FAl_2O_3-POE dan TiO_2-POE. prestasi dalam sistem RAC yang berfungsi dengan penyejuk R410a dan R32, dan (iii) untuk mengoptimumkan operasi kerja pelincir nano FAl_2O_3-POE dan TiO_2-POE untuk sistem RAC menggunakan Kaedah Permukaan Tindak Balas (RSM). Kaedah dua langkah telah diguna pakai untuk merumuskan pelincir nano FAl_2O_3-POE dan TiO_2-POE. Kestabilan pelincir nano ditentukan pada tiga tahap: visual, spektrofotometri boleh dilihat UV, dan potensi zeta. Dalam pelincir nano berasaskan FAl_2O_3 dan TiO2, pencirian kelikatan dinamik dengan RheolabQC menunjukkan peningkatan maksimum masing-masing sebanyak 11.36% dan 16.70%. Sebagai perbandingan, laporan mengenai ujian kekonduksian terma dengan c-Therm menunjukkan peningkatan penuh sebanyak 4.35% dan 3.44%. Dan kemudian, keputusan ujian tribologi mencadangkan pengurangan COF maksimum masing-masing sebanyak 35.8% dan 27.144% dalam pelincir nano FAl_2O_3-POE dan TiO_2-POE. Peningkatan tertinggi dalam COP dalam sistem FAl_2O_3-POE/R410a dan FAl_2O_3-POE/R32 ialah masing-masing 24.59% pada 0.15 vol% dengan 0.442 kg dan 32.26% pada 0.15 vol% dengan 0.442 kg cas penyejuk awal. Dan kemudian, peningkatan tertinggi dalam COP dalam sistem TiO_2-POE/R410a dan TiO_2-POE/R32 ialah masing-masing 14.75% dan 22.58% pada 0.11 vol% dengan 0.442 kg cas penyejuk awal. Penemuan getaran menunjukkan bahawa penggunaan kedua-dua jenis pelincir nano dalam julat 0.02-0.15 vol% adalah selamat untuk kegunaan jangka panjang. Fungsi kemahuan Central Composite Design RSM mencadangkan keadaan operasi optimum untuk semua jenis pelincir nano dengan R410a dan R32 adalah pada kepekatan 0.11 vol% dengan cas penyejuk 0.442 kg. Ralat standard pengoptimuman adalah dalam lingkungan 0.012%-0.024%.

ABSTRACT

Residential Air Conditioning (RAC) system plays important role for everyone's comfort at home and office. This research is determined by a motivation to reduce the global warming effect caused by the RAC system and increase the coefficient of performance (COP) and energy saving. This study proposes the replacement of polyolester (POE) as a conventional lubricant using FAl_2O_3-POE and TiO_2-POE nanolubricants for better performance and efficiency and then replacing the existing refrigerant R410a using R32, which has a lower Global Warming Potential (GWP). The objectives of this study are (i) to characterize the FAl_2O_3-POE and TiO_2-POE nanolubricant thermophysical properties for application in the RAC system working with refrigerant R410a dan R32, and (ii) to evaluate the FAl_2O_3-POE and TiO_2-POE nanolubricant performance in the RAC system working with refrigerant R410a dan R32, and (iii) to optimize the working operation of the FAl_2O_3-POE and TiO_2-POE nanolubricant for RAC system using Response Surface Method (RSM). A two-step method was adopted to formulate FAl_2O_3-POE and TiO_2-POE nanolubricant. The stability of nanolubricants was determined at three levels: visual, UV visible spectrophotometry, and zeta potential. In FAl_2O_3 and TiO_2-based nanolubricants, characterization of dynamic viscosity with RheolabQC showed a maximum increase of 11.36% and 16.70%, respectively. In comparison, a report on thermal conductivity test with c-Therm showed a full augmentation of 4.35% and 3.44%. And then, tribology test results suggest a maximum COF reduction of 35.8% and 27.144% in FAl_2O_3-POE and TiO_2-POE nanolubricants, respectively. The highest increase in COP in the FAl_2O_3-POE/R410a and FAl_2O_3-POE/R32 systems are 24.59% at 0.15 vol% with 0.442 kg and 32.26% at 0.15 vol% with 0.442 kg of initial refrigerant charge, respectively. And then, the highest increase in COP in the TiO_2-POE/R410a and TiO_2-POE/R32 system is 14.75% and 22.58% at 0.11 vol% with 0.442 kg of initial refrigerant charge, respectively. The vibration findings show that using both types of nanolubricant in the range of 0.02-0.15 vol% is allowable for long-term use. The desirability function Central Composite Design RSM suggests the optimum operating conditions for all types of nanolubricants with R410a and R32 are at a concentration of 0.11 vol% with an initial refrigerant charge of 0.442 kg. The standard error of optimization is within 0.012%-0.024%.

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APPENDICES

Appendix A: Thermocouple Calibration Analysis