THERMOPHYSICAL PROPERTIES AND TRIBOLOGICAL BEHAVIOR OF HYBRID CELLULOSE NANOCRYSTAL COPPER (II) OXIDE (CNC-CuO) AS LUBRICANT ADDITIVES

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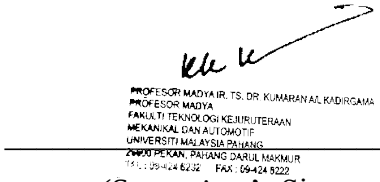

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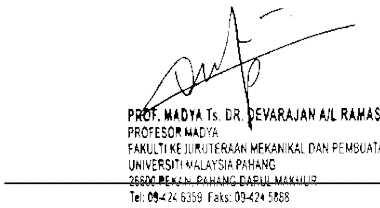

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ABSTRAK

Peningkatan dalam prestasi tribologi di antara pelapik silinder dan cincin piston diperlukan untuk mengoptimumkan penggunaan bahan bakar dan melambatkan masa pemerosotan enjin. Pendekatan baru dengan penggunaan partikel nano di dalam minyak enjin mampu meningkatkan sistem tribologi dan sifat termofizik. Penggunaan partikel nano hibrid bagi organik dan tidak organik menarik minat ramai penyelidik kerana berpotensi dapat menggabungkan ciri kimia, optik dan mekanikal yang berguna. Gabungan pelincir nano organik dan tidak organik dapat meningkatkan pelincir yang mempunyai komponen nano tunggal komponen dalam mencapai peningkatan sifat terma, sifat reologi, kestabilan minyak, sifat termal dah fizikal serta tingkah laku geseran dan haus. Tujuan kajian ini adalah untuk menilai sifat minyak pelincir nano selulosa (CNC) dan kuprum oksida (CuO) dan menyiasat keadaan optimum sifat termal dan fizikal, prestasi geseran dan kehausan menggunakan kombinasi partikel nano organik dan tidak organik yang terbaik. Kepekatan isipadu minyak pelincir nano dibancuh sehing 0.9%. Sifat fizikal dan termal minyak enjin CNC-CuO diukur sehingga dari suhu 30 sehingga 90℃. Sementara itu, sifat tribologi dari minyak pelincir nano dinilai menggunakan parameter beban, kelajuan, suhu dan kepekatan isipadu yang berbeza. Kaedah lengkungan dan *Response Surface Methodology* (RSM) digunakan untuk memprediksi sifat fizikal dan termal serta tribologi. Penilaian kestabilan menunjukkan CNC-CuO mempunyai keadaan kestabilan yang sangat baik tanpa pemendapan dalam tempoh sebulan sebulan. Kestabilan juga dibuktikan dengan mengukur potensi zeta hingga 61.1 mV dan mengekalkan nisbah kepekatan spektrofotometer UV-Vis selama lebih dari 90%. Hasil indeks kelikatan menunjukkan bahawa semakin tinggi kepekatan CNC-CuO, VI semakin bertambah baik. Peningkatan VI adalah 44.3% -47.12%. Kelikatan dinamik, kekonduksian terma dan kapasiti haba spesifik CNC-CuO meningkat dengan kepekatan isipadu dan menurun dengan suhu. Peningkatan maksimum dalam kelikatan dinamik masing-masing adalah 74.81%, yang berlaku pada suhu 90 ° C pada kepekatan 0.5%. Peningkatan maksimum dalam kelikatan dinamik masing-masing adalah 74.81%, yang berlaku pada suhu 90℃ pada kepekatan 0.5%. Peningkatan maksimum nisbah kekonduksian terma dari minyak enjin nano adalah 1.80566 dan didapati kepekatan 0.1% di suhu 90 ℃. Untuk kapasiti haba spesifik, 0.5% adalah kepekatan optimum jika dibandingkan dengan minyak enjin biasa. Korelasi termofisik dan tribologi yang dicadangkan dapat memprediksi skerana margin penyimpangan lebih dekat dengan titik-titik yang terletak di bahagian dua. Hasil menunjukkan bahawa CNC-CuO mengurangkan pekali geseran masing-masing sebanyak 48.50%, 33.44% dan 9–13% di bawah had, campuran dan hidrodinamik. Diperhatikan bahawa beberapa fenomena *scuffing* dan pengelupasan yang teruk berlaku pada sampel SAE 40 sementara *scuffing* yang ringan dijumpai pada CNC-CuO. Goresan yang besar juga berlaku kerana koyakan mikro-abrasive. Teknologi hijau yang baik untuk alam sekitar dan semakan ketahanan enjin boleh dilakukan untuk penyelidikan masa hadapan.

ABSTRACT

Enhancement in the tribological behaviour of piston ring-cylinder liner contact is necessary to reduce the fuel consumption and elongate the engine time deterioration. A novel approach for improving the tribological system and thermophysical properties are dispersing nanoparticles in SAE 40 engine oil. The organic-inorganic nanolubricants is expected to improve the properties of single component nanolubricants in achieving enhancement in thermal properties, rheological properties, stability, thermophysical properties and friction and wear behaviour. The present study aims to evaluate the thermophysical properties of CNC-CuO nanolubricants, investigate the tribological behaviour of CNC-CuO nanolubricant and investigate the optimum condition of the thermophysical properties, friction and wear performance. The nanolubricants was prepared up to 0.9% volume concentration. Thermophysical properties of CNC-CuO nanolubricants were measured at the temperature of 30°C to 90 °C. Meanwhile, tribological properties of the nanolubricants were evaluated for different loads, speeds, temperature and volume concentration. The curve fitting method and Response Surface Methodology (RSM) were used to predict the thermophysical and tribological properties. Response Surface Methodology (RSM) methods were also selected to optimize the thermophysical and tribological friction behaviour. Stability evaluation showed CNC-CuO nanolubricants having an excellent stability condition with no sedimentation observed within a month. It was proven by measuring the zeta potential up to 61.1 mV and maintaining the UV-Vis spectrophotometer's concentration ratio for more than 90%. The viscosity index result shows that the higher the concentration, the VI is improved. VI enhancement is 44.3%-47.12%. Dynamic viscosity, thermal conductivity and specific heat capacity of CNC-CuO nanolubricants increased with volume concentration and decreased with temperature. Maximum enhancement in the dynamic viscosity was 74.81%, respectively, which occurred at the temperature of 90°C at 0.5% concentration. The maximum increase of thermal conductivity was 1.80566 for a volume concentration of 0.1% at 90℃. For specific heat capacity,0.5% is the optimum concentration compared with the base fluid. The proposed correlation of the thermophysical and tribological was considered to predict the properties as the margin of deviation is closer to the points located on the bisector. The results showed that the CNC-CuO nanolubricants reduced the friction coefficient by 48-50%, 33-44%, and 9–13% under boundary, mixed, and hydrodynamic lubrication. It is observed that some severe scuffing and exfoliations phenomenon occurred in SAE 40 sample while light scuffing was found on the CNC-CuO nanolubricant. The extensive scratches happened due to micro-abrasive wear. As an overall conclusion, the addition of CNC-CuO nanoparticles into the engine oil enhances thermophysical properties and tribological behaviour with the optimum concentration at 0.5%.

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