THE EFFECT OF OXYGENATED TURPENTINE AND ALPHA PINENE OIL ADDITIVES IN DIESEL FUEL ON THE PERFORMANCE, COMBUSTION, AND EMISSIONS IN DIESEL ENGINE

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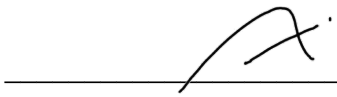
We hereby declare that We have checked this thesis and, in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.



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ABSTRAK

Pembakaran diesel mengeluarkan gas berbahaya seperti CO_2 dan NO_X. Pencampuran bahan api diesel dengan bahan tambahan adalah salah satu daripada pelbagai usaha untuk mengurangkan gas hasil dari pembakaran minyak diesel dan untuk mengoptimumkan penggunaan bahan api dalam enjin. Minyak turpentin dan alfa pinene mempunyai potensi sebagai bio-aditif dalam minyak diesel kerana sifat-sifatnya yang rendah kelikatan, nilai kalori yang tinggi, serta kandungan oksigen yang tinggi. Tujuan penyelidikan ini adalah untuk mengkaji sifat fizikokimia, prestasi, pembakaran, dan ciri pelepasan gas ekzos diesel dengan tambahan bio-aditif dari minyak turpentine, minyak turpentin beroksigen, minyak alfa pinene, dan alfa pinene beroksigen dalam enjin pencucuh mampatan suntikan langsung satu silinder, serta menyimpulkan model regresi baru prestasi enjin, pembakaran, dan ciri pelepasan gas ekzos. Kajian ini dilakukan menggunakan enjin pencucuh mampatan Yanmar TF120M silinder tunggal yang tidak diubah suai pada beban rendah, sederhana, dan tinggi yang berterusan di bawah kelajuan enjin dari 1,200 rpm hingga 2,400 rpm dengan selang 200 rpm. Bahan tambahan atau bio-aditif, iaitu turpentin, alfa pinene, turpentin beroksigen, dan alfa pinene beroksigen diadun dengan minyak diesel dan dimasukkan ke dalam enjin untuk mengenal pasti prestasi, pembakaran, dan pelepasan gasnya. Model regresi telah dihasilkan menggunakan metodologi permukaan tindak balas untuk meramalkan prestasi engine, pembakaran minyak dan pelepasan gas. Hasil yang didapati menunjukkan bahawa komposisi kimia minyak turpentin dan turpentin beroksigen mengandungi sebatian kimia yang lebih tinggi daripada diesel. Ketumpatan dan nilai kalori bahan api ujian dengan tambahan bio-aditif adalah lebih tinggi berbanding diesel sebanyak 2.25% dan 5.92%. Kelikatan kinematik dan nombor cetane bahan api ujian dengan tambahan bio-aditif adalah 14.76% dan 5.23% lebih rendah berbanding minyak diesel. Hasil juga mendapati terdapat peningkatan kuasa brek, kecekapan haba brek, penggunaan bahan api khusus brek dan suhu gas ekzos bahan bakar api ujian dengan tambahan bio-aditif dalam diesel sehingga 7.33%, 24%, 8% dan 20.06%, bagi setiap parameter. Tekanan dalam silinder puncak dan kadar pelepasan haba puncak bahan api ujian dengan tambahan bio-aditif adalah 6.15% dan 11.32% lebih tinggi daripada diesel. Hasi kajian juga menunjukkan pelepasan gas ekzos karbon dioksida dan nitrogen oksida bahan api ujian dengan tambahan bio-aditif adalah 16.88% dan 22.79% lebih tinggi daripada diesel, manakala karbon monoksida hampir sama dengan diesel. Analisis varians (ANOVA) hasil daripada eksperimen menunjukkan tahap keyakinan sebanyak 99.5%, maka model regrasi yang dihasilkan adalah penting. Perbandingan output eksperimen dengan ramalan dari model yang dibangunkan adalah berdekatan dan mempunyai pekali korelasi R^2 yang tinggi untuk pelbagai pembolehubah tindak balas. Secara keseluruhan, kajian ini menyimpulkan bahawa minyak turpentin beroksigen dan alfa pinene beroksigen mempunyai potensi untuk digunakan sebagai bahan api tambahan dalam enjin pencucuh mampatan pada masa akan datang.

ABSTRACT

Diesel combustion emitted harmful gases emissions such as CO_2 and NO_X. Mixing diesel fuel with additives is one of the many attempts to reduce emissions from diesel combustion, as well to optimize fuel consumption of the engine. Turpentine oil and alpha pinene have high potential as bio-additive in diesel due to its properties, low viscosity, high calorific value, and high oxygen content. The aim of this research is to determine the physicochemical properties, performance, combustion, and exhaust emission characteristics of diesel with bio-additives from turpentine oil, oxygenated turpentine oil, alpha pinene oil, and oxygenated alpha pinene in a single-cylinder direct injection compression ignition engine, and to formulate new regression models of engine performance, combustion, and emission characteristics. The experiment was performed using a single cylinder unmodified Yanmar TF120M compression ignition engine at low, medium, and high loads under various engine speeds from 1200 rpm to 2400 rpm with 200 rpm interval. The additives, namely, turpentine, alpha pinene, oxygenated turpentine, and oxygenated alpha pinene were blended in diesel and used in the engine in order to identify its performance, combustion, and emission characteristics. Regression models were developed using the response surface methodology to predict the significant of engine performance and emission parameters. The results revealed that chemical composition of turpentine and oxygenated turpentine contains chemical compounds with higher volatility than diesel, density and calorific values of the test fuels with additives are higher than diesel 2.25% and 5.92%, respectively, while kinematic viscosity and cetane number of the test fuels with additives 14.76% and 5.23%, respectively, lower than diesel. The result also shows there are improvement of brake power, brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature of test fuel with additives in diesel up to 7.33%, 24%, 8% and 20.06%, respectively. Peak in-cylinder pressure and peak heat release rate of test fuels with additives are 6.15% and 11.32% higher than diesel. The finding also shows carbon dioxide and nitrogen oxide exhaust emission of test fuels with additives 16.88% and 22.79% than diesel, while carbon monoxide are almost similar with diesel. Analysis of variance (ANOVA) of the experimental results at 99.5% confidence level exposed that the developed models are significant. Comparison of experimental output with those predicted by the developed models indicated close proximity having high correlation coefficients R^2 for the various response variables. Overall, this study concluded that the turpentine and alpha pinene oil have a potential to be use as a bio-additive fuel for compression ignition engines in the future.

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