ANALYSIS OF ANTIOXIDANT ADDITIVES-BIODIESEL BLENDS ON ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS OF A DIESEL ENGINE

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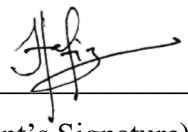
I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.



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ABSTRAK

Lebihan kadar oksigen di dalam campuran biodiesel meningkatkan pelepasan nitrogen oksida kerana mempunyai suhu pembakaran yang lebih tinggi dapat dikurangkan dengan menambah aditif antioksidan ke dalam campuran. Kajian dijalankan terhadap enjin diesel mengunakan campuran biodiesel dengan aditif antioksidan menggunakan analisis variasi kitaran pembakaran adalah terhad yang memerlukan kajian yang lebih mendalam. Tujuan kajian ini adalah untuk mengkaji kesan campuran aditif antioksidan-biodisel terhadap karakteristik pembakaran, prestasi dan pelepasan asap ekzos daripada enjin diesel satu silinder suntikan terus pada kelajuan tetap pada 1800 rpm dengan berlainan beban enjin. Bahan api diesel (DF), campuran biodiesel kelapa sawit (B20), B20 + 1000 ppm antioksidan *Butylated hydroxyanisole* (BHA) (B2HA1.0), B20 + 1500 ppm antioksidan BHA (B2HA1.5), B20 + 1000 ppm antioksidan *Butylated hydroxytoluene* (BHT) (B2HT1.0), and B20 + 1500 ppm antioksidan BHT (B2HT1.5) digunakan di dalam kajian ini. Kajian merangkumi variasi kitaran pembakaran dari profil tekanan silinder dan tekanan maksimum silinder dengan 200 kitaran berturut-turut untuk mengkaji variasi kitaran pembakaran untuk setiap bahan api yang digunakan pada pelbagai kondisi. Maklumat tersebut dinilai secara statistik untuk memperoleh pekali variasi untuk tekanan silinder maksimum. Dalam masa yang sama, prestasi dan perlepasan asap enjin dianalisa dengan metodologi tindak balas permukaan untuk membina model regresi. Dapatan kajian mendapati, terdapat pengurangan tekanan silinder dan kadar perlepasan haba sebanyak (0.47% - 5.78%) and (1.55% - 15.29%). Pekali variasi untuk tekanan silinder maksimum untuk campuran antioksidan-biodisel didapati lebih tinggi pada maksimum 36.36% dibandingkan dengan B20. Brek penggunaan bahan api tertentu campuran antioksidan-biodisel menuruun (2% - 15%) manakala kecekapan brek baha enjin meningkat (7.4% - 36.0%) dibandingkan dengan B20. Selanjutnya, aditif antiosida BHA lebih baik dalam mengurangkan pelepasan nitrogen oksida dengan purata penurunan tertinggi iaitu 30.5%. Walau bagaimanapun, peningkatan maksimum pelepasan karbon monoksida (26.6%) dan hidrokarbon (27.1%) dicatatkan dibandingkan dengan B20. Analisis varians eksperimen menghasilkan tahap keyakinan pada 95% menunjukkan model yang dibina adalah signifikasi dengan mempunyai pekali kolerasi R^2 tinggi untuk pelbagai pemboleh-ubah tindak balas. Oleh itu, di dalam kajian ini, B2HA1.0 paling berkesan untuk mengurangkan pelepasan nitrogen oksida tetapi menghasilkan variasi kitaran yang lebih tinggi. Dapatan ini dapat memberikan pemahaman penting mengenai campuran aditif antioksidan-biodisel yang menawarkan maklumat tambahan untuk mengurangkan pelepasan nitrogen oksida.

ABSTRACT

Excess of oxygen content in biodiesel blends increased Nitrogen oxides (NO_x) emission due to having a higher temperature combustion that can be mitigated by adding antioxidant additives into the blends. There is limited study conducted on the combustion, performance and emission characteristics of a diesel engine running on antioxidant additives-biodiesel blends that need a deeper understanding. This study aims to investigate the effect of antioxidant additives-biodiesel blends on engine combustion, performance, and emission characteristics of a single-cylinder direct injection diesel engine at a constant speed of 1800 rpm under various engine loads. A diesel fuel (DF), palm biodiesel blends (B20), B20 + 1000 ppm Butylated hydroxyanisole (BHA) antioxidant (B2HA1.0), B20 + 1500 ppm BHA antioxidant (B2HA1.5), B20 + 1000 ppm Butylated hydroxytoluene (BHT) antioxidant (B2HT1.0), and B20 + 1500 ppm BHT antioxidant (B2HT1.5) fuels are used in this study. Investigational works recorded cyclic combustion variations of cylinder pressure profiles of 200 consecutive cycles to assess the cyclic combustion variations. Those pieces of information were statistically evaluated to acquire the coefficient of variation (COV) for peak cylinder pressure (P_{max}). At the same time, the engine performance and emission characteristics were analysed with response surface methodology (RSM) to develop a regression model. The finding shows a reduction in cylinder pressure and heat release rate by (0.47% - 5.78%) and (1.55% - 15.29%), respectively. $COVP_{max}$ for antioxidant additives-biodiesel blends was discovered to be higher at a maximum of 36.36% than B20. The brake specific fuel consumption of antioxidant additives-biodiesel blends was reduced (2% - 15%), whereas brake thermal efficiency increased (7.4% - 36.0%) compared to B20. Furthermore, BHA antioxidant additives perform better in reducing NO_x emissions, with the highest reduction average of 30.5%. However, a maximum increase of carbon monoxide (26.6%) and hydrocarbon emission increase (27.1%) were recorded compared to B20. Analysis of variance (ANOVA) of experimental result shows a 95% confidence level that indicates the developed models are significant with high correlation coefficients R^2 for the various response variables. Hence, in this study, B2HA1.0 shows the most effective to reduce NO_x emission but produces higher cyclic variations. In general, these results have donated an essential understanding of the antioxidant additives-biodiesel blends operating with engines and offer supplementary information to reduce NO_x emissions.

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