GRAPHENE ADDITIVE EFFECTS ON DIESEL BLEND FUELS FOR PERFORMANCE, COMBUSTION AND EMISSIONS ON DIESEL ENGINE

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DOCTOR OF PHILOSOPHY

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SUPERVISOR'S DECLARATION

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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STUDENT'S DECLARATION

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

Pemanasan global dan kesan rumah hijau masih menjadi isu dunia dalam waktu kini dan pada masa hadapan walaupun kemajuan telah dicapai dalam bahan bakar alternatif. Pembakaran bahan bakar fosil oleh enjin pembakaran dalam seperti kereta persendirian, kenderaan perdagangan dan pengangkutan lain menjadi sumber utama pencemaran udara. Pelbagai cara boleh digunakan untuk mengurangkan pencemaran seperti mengurangkan berat kenderaan, penggunaan bahan bakar alternatif dan penggunaan bahan tambahan dalam bahan bakar. Beberapa kajian telah dilakukan oleh penyelidik-penyelidik untuk mengetahui kesan-kesan penggunaan "graphene nanoplatelets" sebagai bahan tambahan dalam enjin diesel. Kajian ini bertujuan untuk mendalami kesan tambahan "graphene nanoplatelets" terhadap sifat-sifat fizik dan kimia serta kesan terhadap prestasi dan pencemaran udara enjin diesel. Tambahan pula, kajian ini bertujuan membuat ramalan berkomputer kesan penggunaan bancuhan diesel-graphene terhadap prestasi dan pencemaran enjin diesel. Di dalam kajian ini juga, sifat-sifat fizik dan kimia bancuhan diesel-graphene (ketumpatan, kelikatan, dan nilai kalori) telah diuji berdasarkan piawaian ASTM. Sifat-sifat ini dibandingkan pula dengan sifat-sifat diesel asli, yang digunakan sebagai garis asas dalam kajian ini. Kestabilan bancuhan juga diuji menggunakan pemerhatian visual dan UV-Vis. Kemudiannya bancuhan ini digunakan untuk menghidupkan enjin diesel satu silinder. Enjin dijalankan dengan lima kelajuan berbeza (900, 1200, 1500, 1500, and 2100) rpm, enam beban berbeza (0, 20, 40, 60, 80, dan 100)%, dan lima bancuhan berbeza (0, 25, 50. 75, dan 100) ppm. Keputusan eksperimen dianalisis dengan menggunakan statistik asas, carta palang dan plot terabur. Minitab® ialah perisian yang dipilih untuk menghasilkan model ramalan. Plot permukaan dan plot kontur pula digunakan untuk simulasi nilai ramalan. Hasil ujian sifat-sifat bancuhan minyak menunjukkan penambahan bahan tambahan "graphene nanoplatelets" telah meningkatkan ketumpatan dan kelikatan diesel. Walaubagaimanapun, nilai kalori bancuhan didapati lebih rendah berbanding diesel asli. Keputusan eksperimen menunjukkan peningkatan kilasan, kuasa, penggunaan minyak spesifik, dan kecekapan haba pada beban yang tinggi (80% - 100%). Tambahan pula, pelepasan CO_2 dan NO_x telah berjaya dikurangkan pada semua beban (0% - 100%). Namun begitu, pelepasan CO hanya berkurangan pada beban tinggi (100%) tetapi meningkat secara minima pada beban rendah. Model ramalan yang menggunakan kaedah respon permukaan untuk semua parameter (kilasan, kuasa, penggunaan minyak spesifik, dan kecekapan haba) telah berjaya dihasilkan. Semua model menunjukkan persamaan bila dibandingkan dengan nilai yang diperolehi daripada eksperimen (perbezaan kurang daripada ±10%). Tambahan pula, model ramalan untuk parameter pelepasan asap (CO, CO_2, dan NO_x) juga telah berjaya dihasilkan. Semua model telah menunjukkan persamaan yang baik dengan nilai eksperimen (perbezaan kurang daripada ±10%), kecuali model ramalan untuk CO tidak menunjukkan persamaan yang baik. Ini disebabkan oleh bacaan CO yang sangat rendah. Kesimpulannya, kajian ini telah berjaya menentukan kesan tambahan "graphene nanoplatelets" terhadap sifat-sifat fizikal dan kimia terhadap bancuhan diesel-graphene. Eksperimen yang dijalankan juga telah berjaya mempamerkan kesan bancuhan diesel-graphene terhadap prestasi dan pelepasan asap enjin diesel satu silinder. Seterusnya, kajian ini juga telah berjaya menghasilkan model ramalan yang realistik untuk kesan penggunaan bancuhan diesel-graphene terhadap prestasi dan pelepasan asap enjin diesel.

ABSTRACT

The trend of global warming and greenhouse emissions remains as is for the foreseeable future, despite the advancements made in alternative fuels. The burning of fossil fuels in the internal combustion engines of private cars, commercial vehicles, and other modes of transportation is the primary source of emissions. Various ways can reduce emissions, such as reducing vehicle weight, using alternative energy sources, and adding additives to the fuels. Researchers have performed a few studies to study the effects of graphene nanoplatelets' application as an additive in diesel engines. This research aims to analyse the physicochemical properties of the diesel-graphene mixture and to evaluate the effect of performance and emissions of diesel-graphene blends in a single cylinder CI engine. Furthermore, this research aims to predict the effect of performance and emissions of diesel-graphene blends in a compression ignition engine through analytical and computational methods. In this research, the physicochemical properties of the diesel-graphene blends (density, viscosity, and calorific value) were tested using ASTM standards. The properties are then compared to fuel diesel, which was used as the baseline in this study. The stability of the blends was also tested using visual observation and UV-Vis spectroscopy. The fuel blends were then run in a single-cylinder diesel engine. The engine was run with five different speeds (900, 1200, 1500, 1800, and 2100) rpm, six different loads (0, 20, 40, 60, 80, and 100) %, and five different blends (0, 25, 50, 75, and 100) ppm. The experiment results were analysed with basic statistics, bar charts, and scatterplots. Minitab® is the tool chosen to produce the prediction model. The response surface methodology is applied in producing the prediction model. Surface and contour plots were used to simulate the predicted values. The results from the property tests showed that the addition of graphene nanoplatelets increased the viscosity and density of the diesel. However, the calorific value of the blends is found to be lower than pure diesel. The results from the experiments indicated improvement in brake torque, brake power, brake specific fuel consumption, and brake thermal efficiency at high loads (80% - 100%). Moreover, the emission of CO_2 and NO_x have been reduced at all different loads. However, the emission of CO was only reduced at high loads (100%) but increased at lower loads. The prediction model using response surface methodology for all parameters (Torque, Power, BSFC, and BTE) has been established. All the models showed good agreement compared with the experimental data (less than ±10%). In addition, a prediction model for all emission parameters (CO, CO_2, and NO_x) have been established. All the models showed good agreement compared with the experimental data (less than ±10%), except the prediction model for CO did not show good agreement due to the fact this is diesel engine emission- which reflects CO value to be extremely low and even negligible. In conclusion, this research has successfully determined the effects of graphene nanoplatelets on the physicochemical properties of diesel-graphene blends. The experiments also successfully demonstrated the effects of diesel-graphene blends on the performance and emissions of a single-cylinder compression ignition engine. Additionally, this study also managed to produce a realistic prediction model for the effects of graphene nanoplatelets usage as an additive to diesel engine performance and emissions.

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