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EXHAUST EMISSIONS OF A DIESEL ENGINE FUELLED WITH CRUDE PALM OIL-DIESEL BLENDED EMULSION

Danial Hakeem Safarihairol *, Wira Jazair Yahya, Mohamed Shukri Mohamed Ismail
Faculty of Malaysia–Japan International Institute of Technology, Universiti Teknologi Malaysia, 54100 UTM Kuala Lumpur, Kuala Lumpur, Malaysia.
* Corresponding author: danialhakeem@graduate.utm.my

ABSTRACT

Petroleum diesel is running out, so there's a big push to find alternatives like biofuels. Using neat crude palm oil (CPO) is popular, but it often leads to more emissions and higher fuel consumption. Emulsifying CPO with diesel could help reduce emissions. An experiment compared diesel, CPO, and a diesel/CPO blend called CPO-Diesel Water Emulsion (CDWE). CDWE, with 45% diesel, 45% CPO, and 10% water, performed best, especially at 50% and 100% loads, reducing fuel consumption by over 26% compared to diesel. CPO emitted significantly less nitrogen oxide (NOx) than diesel and CDWE, with CDWE emitting 26.7% less NOx than diesel on average. At higher loads, CDWE emitted less carbon monoxide (CO) and smoke than diesel or CPO, especially at 100% load. While CDWE's carbon dioxide (CO_2) emissions were similar to other fuels on average, they surpassed diesel's at 100% load. Exhaust gas temperature (EGT) didn't differ much between fuels. Overall, CDWE shows promise as a cleaner alternative to diesel.

KEYWORD

Diesel, crude palm oil, emissions, blended emulsion fuel, alternative fuel

INTRODUCTION

Diesel engines have played an important role across various sectors like transportation, power generation, agriculture, and civil works since Rudolf Diesel's first prototype in 1897. However, the finite nature of petroleum diesel highlights the urgency of seeking alternative energy sources. While solar and wind power are clean options, their unpredictable nature limits consistent output. Biodiesel, derived from processes like transesterification of straight vegetable oil (SVO), has gained traction in countries like Malaysia and Indonesia, where biodiesel crops are abundant, with Malaysia incorporating a B10 blend and Indonesia pioneering 100% palm oil biodiesel.

Despite being a promising alternative, crude palm oil (CPO) presents challenges, notably higher emissions than diesel. Direct CPO use in diesel engines emits elevated nitrogen oxides (NOx) and carbon monoxide (CO), attributed to poor fuel atomisation and high oxygen content. These emissions contribute to environmental issues like water pollution, climate change, and acid rain, accentuating the need for cleaner solutions.

Efforts to enhance CPO performance and emissions include blending with diesel to mitigate viscosity issues and exploring emulsification with water. Emulsified fuels, taking advantage of the micro-explosion phenomena, show potential in reducing NOx and CO emissions, although dependency on surfactants raises production costs. Real-Time Non-Surfactant Emulsion Fuel Supply Systems (RTES) offer a promising avenue to commercialize emulsion fuels. This study aims to evaluate the performance and emissions of a single-cylinder diesel engine fuelled with crude palm oil emulsion, utilizing RTES to ensure homogeneous combustion across varying loads.

MATERIAL AND METHODOLOGY

The Benma 5GF-ME generator as shown in Figure 1 was utilised in this study. The Benma 5GF-ME is a 1-cylinder, 4-stroke, air-cooled with direct injection generator. The Real-Time Non-Surfactant Emulsion Fuel Supply System (RTES) with the latest design, was installed externally to the generator to create a stable emulsion of diesel and preheated crude palm oil (CPO). The RTES incorporates a static mixer to produce fine water droplets, crucial for emulsion stability. The

experiment utilises diesel obtained from Petron Diesel Max and CPO sourced from Sime Darby Jomalina Refinery. CPO was preheated to 80°C before being mixed with diesel to create a single emulsion fuel, CDWE, consisting of 45% CPO, 45% diesel, and 10% water content.

Electrical loads ranging from 1 kW to 4 kW were applied using Philips QVF 137 Halolite lamps, with fuel consumption measured with a burette. The experiment started by refilling the fuel in the burette to 0 ml, running the generator for 2 minutes, and recording the final volume to determine fuel consumption. Sauermann Si-CA 130 emission analyser was used to measure exhaust gas temperature and emissions of NOx, CO, and CO_2. The Horiba MEXA-600S opacimeter on the other hand was used to measure smoke emissions. Data were collected every five seconds over two minutes. Before each trial, a 15-minute purging period was conducted, and the emission analyser was connected to a smartphone via Bluetooth for data collection. Data analysis involved Excel-based cleaning procedures to remove outliers, with quartile functions utilised to identify and eliminate data points falling outside the interquartile range (IQR).

Figure 1: Benma 5GF-ME generator

RESULT AND DISCUSSION

CPO consistently exhibits the highest fuel consumption, attributed to its lower heating value and higher density, requiring a larger mass fuel for engine operation. Conversely, CDWE initially shows similar fuel consumption to diesel but experiences a decrease as load increases, with the most significant reduction exceeding 26% at full load, facilitated by enhanced combustion qualities such as increased ignition delay and micro-explosion phenomena. Regarding exhaust gas temperature (EGT), CPO registers a 5.77% average increment relative to diesel due to poor atomization during combustion and its low cetane number, whereas CDWE demonstrates only a 3.38% decrease on average compared to diesel, albeit showing a trend similar to CPO. Figures 2, 3, 4 and 5 illustrate the emissions of NO_X, CO, CO_2 and smoke respectively for each fuel, showcasing CDWE's potential in reducing emissions, particularly evident in its steady decrement of CO emissions with increasing load, attributed to micro-explosion phenomena enhancing combustion efficiency and minimizing smoke emission increment compared to diesel and CPO under varying loads.

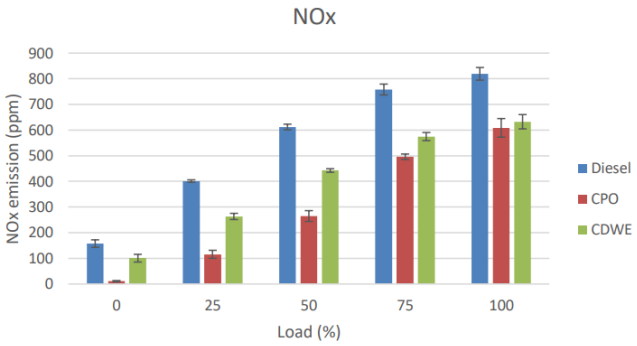

Figure 2: NOx emissions

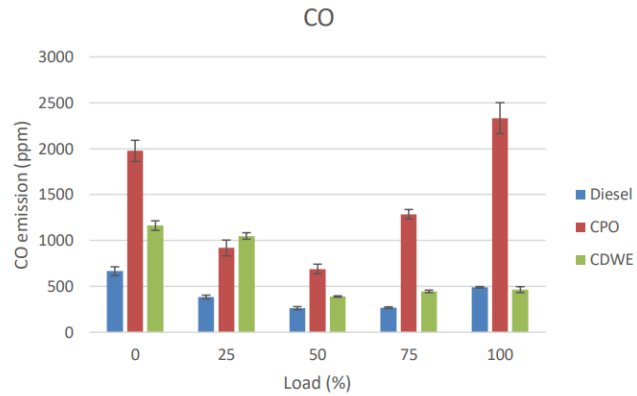

Figure 3: CO emissions

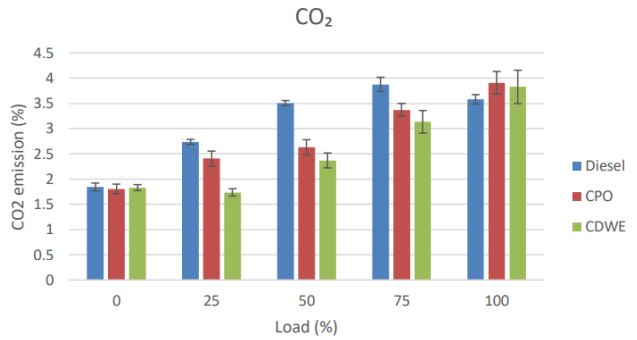

Figure 4: CO_2 emissions

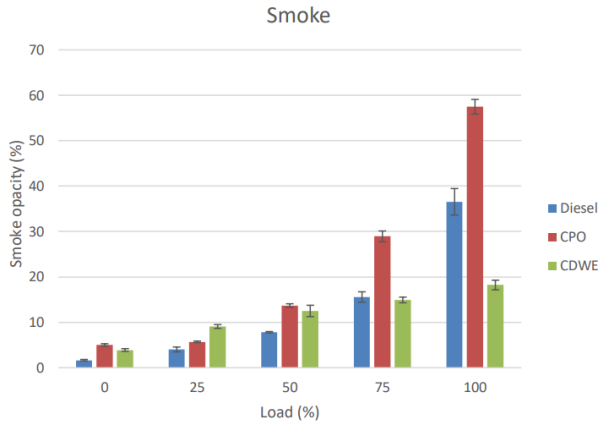

Figure 5: Smoke emissions

CONCLUSION

In conclusion, this study investigated a CPO emulsion consisting of 45% CPO, 45% diesel, and 10% water, created using RTES, and tested its impact on generator performance and exhaust emissions. Engine performance metrics such as fuel consumption (FC) and exhaust gas temperature (EGT) were assessed, alongside gas emissions including NO_X, CO, CO_2 and smoke. Results indicated improved engine performance with CDWE, showcasing the lowest FC throughout the experiment, achieving over a 26% reduction at maximum load. EGT showed a slight decrease of 3.38% compared to diesel. In terms of emissions, CDWE and CPO exhibited lower NOx emissions than diesel, with reductions of 26.73% and 45.57% on average, respectively. CDWE also demonstrated improved CO emissions, being lowest at 100% load, attributed to enhanced combustion efficiency. Smoke emissions decreased by an average of -10.62% compared to diesel, with significant improvement observed between 50% to 100% load conditions. Overall, CDWE produced from RTES showed enhanced engine performance and reduced exhaust emissions in a single-cylinder diesel engine.

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