

EXPERIMENTAL INVESTIGATION ON CI ENGINE USING NON-EDIBLE BIODIESEL WITH OXY-GAS GENERATOR

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ABSTRACT

Since biodiesel is a renewable type of fuel, as well as produces low levels of emissions compared to conventional diesel, its usage has significantly increased recently. Apart from using biodiesel as a cleaner alternative for conventional diesel, other ways of enhancing the performance of the diesel engine, and minimizing emissions include employing H₂ rich gas as fuel enhancer and using EGR systems for diesel engines. This investigation involved the use of a four-stroke direct injection (DI) diesel engine with various percentages of silk cotton seed biodiesel mixed with diesel and HHO at a rate of 2 LPM and 4 LPM introduced into the intake manifold through electrolysis. This was done to enhance the performance of the engine through the assumed synergism between the two fuels. In addition, the same engine, under similar load parameters (that is 0, 25, 50, 75 and 100% loads) was employed to determine the effects of EGR on the emission resulting from the same combination of fuel. The findings revealed that biodiesel in conjunction with hydrogen enhanced combustion improves the performance of the engine, thus being viable alternatives in CI diesel engines.

1. INTRODUCTION:

The use of diesel engines plays an important role in global economic activities. Nonetheless, these diesel engines require non-renewable sources of energy, which produce harmful pollutants that will one day become scarce. Therefore, there is a need to explore renewable sources of energy for powering diesel engines. The use of renewable biobased fuels, such as biodiesel, has been suggested as an alternative source of fuel to common diesel fuel. However, biodiesel suffers from several disadvantages including low energy content and high viscosity compared to diesel fuel. One objective of this study is to investigate the effects of using hydrogen (HHO) with biodiesel in order to overcome some of the deficiencies observed in biodiesel. This is because hydrogen fuel is clean burning and has very fast flame velocities during combustion, thus offering good catalytic properties when used alongside biodiesel. In order to achieve this objective, this study investigated the effects of combining hydrogen (HHO) fuel with conventional diesel fuel, biodiesel, and biodiesel blends (B10, B20, B30) under varying loads on engine performance (as measured by brake thermal efficiency) and emissions (CO & NO_x).

2. MATERIALS AND METHODS:

2.1 Fuel Preparation:

After being harvested and cleaned, the oil from silk cotton seeds is extracted using solvent extraction methods. Before transesterification process with methanol, the extracted oil is pre-processed to remove any unwanted material. Once completed, the biodiesel will be blended at three separate ratios with conventional diesel (i.e., 10% B10, and 20% B20).

2.2 HHO Generation and Induction:

Produced through water electrolysis, hydrogen-infused HHO gas was applied directly at the engine's intake manifold. An adjusted rotameter controlled the gas induction system at a constant gas flow that could be delivered in volumes of 2 litres per minute (LPM) and 4 LPM. The operation was protected by installing a flame arrestor.

2.3 Experimental Setup:

The experiments were conducted on a single-cylinder, four-stroke, variable compression ratio (VCR) CI diesel engine connected to an eddy current dynamometer for load application.

* Engine Speed: Maintained constantly at 1500 RPM.

* Measurements: Fuel consumption, exhaust gas temperatures, and cylinder pressures were recorded.

* Emission Analysis: Exhaust gases (CO, HC, CO₂, NO_x) was measured using an exhaust gas analyser, and a smoke meter was used to determine smoke opacity.

* EGR System: A control valve returned a portion of exhaust gases back to the intake at controlled rates of 5%, 10%, and 15%.

3. RESULTS AND DISCUSSION:

3.1 Performance Characteristics:

- Brake Thermal Efficiency (BTE): When testing various fuels at increasing levels of engine load, the brake thermal efficiency (BTE) improved. The diesel fuel tested provided a maximum BTE of 28.45% and the B10 biodiesel blend had a maximum BTE of 28.25%. The lower BTE seen in the B10 biodiesel was due to the lower calorific value relative to clean diesel fuel. However, the use of HHO gas in the fuel mixture greatly enhanced combustion efficiency to produce a maximum BTE of 31.21% for the B10 biodiesel at 4 LPM of HHO while being used with HHO gas.
- Brake Specific Fuel Consumption (BSFC): Whereas both biodiesel and diesel showed reductions in BSFC when the load increases, the BSFC for diesel reached its peak value, approximately 0.30 kg/kWh, under full load conditions. In regard to biodiesel blends, the BSFC values were higher compared to those observed in diesel blends. It can be seen from the results that incorporation of HHO in the biodiesel blend increased the yield of biodiesel fuel used. The end result was B10 + HHO, which gave the minimum value of BSFC in B10 and/or diesel, that is 0.26 kg/kWh.

3.2 Emission Characteristics:

- Carbon Monoxide (CO) & Hydrocarbons (HC): Both CO and HC emissions decreased with an increase in load on the engine because the in-cylinder temperature increased allowing for increased complete oxidation. Also, biodiesel contains more oxygen than conventional diesel fuel so CO and HC emissions from biodiesel are reduced as compared to those from conventional diesel fuel. The design utilizing B10 + HHO (4 LPM) produced the lowest CO (0.03%) and HC (6 ppm) emissions at full load, as the hydrogen provided a flame velocity that allowed for nearly complete combustion.
- Smoke Opacity: At full engine capacity, the smoke generated using straight diesel fuel reached 21.97%. The addition of hydrogen significantly reduced smoke levels (14.8% with 10% biodiesel and 4 litres per minute of hydrogen). Hydrogen has no carbon atoms in its composition, thus producing no smoke when combusted.
- Nitrogen Oxides (NO_x): No_x creation was proportional with engine loading and combustion temperature. Hydrogen fuel results in an increase in the combustion rate of the fuel and peak in-cylinder temperatures increasing No_x emissions for the B10 + HHO (4 LPM) configuration reaching a peak concentration of 1300 ppm (parts per million) whereas the standard diesel fuel reached only 1124 ppm.

3.3 Effect of Exhaust Gas Recirculation (EGR):

Using HHO as a fuel source allows for the incorporation of an EGR, which helps reduce NO_x created by combustion using HHO. An EGR at 15% had the highest efficiency of reducing NO_x by lowering peak combustion temperatures and lowering the oxygen level in the combustion stream due to dilution. Slightly lowering overall combustion intensity was experienced due to the additional dilution (and thus reduced brake thermal efficiency) of the engine due to hydrogen contributing to the overall stability of combustion.

4. CONCLUSION:

This result highlights the advantages of dual-fuel system in CI engine efficiencies and emissions. The key findings include:

- Hydrogen addition to non-food biodiesel produced from silk cotton seeds compensates for the low calorific content of this type of biodiesel, thus improving engine performance.
- It was established that the most effective combination would be biodiesel with 4 Liters per minute hydrogen addition (B10+4LPM HHO), resulting in 31.21% brake thermal efficiency (BTE) and 0.26 kg/kW hr specific fuel consumption (BSFC). Analysis also revealed that hydrogen-assisted biodiesel greatly reduces incomplete combustion emissions like CO, HC, and smoke.
- Although hydrogen causes increased thermal NO_x generation, it is crucial and efficient to use EGR in such engines.

REFERENCES:

1. Agarwal, A. K., & Dhar, A. (2014). Experimental investigations of performance, emission and combustion characteristics of Karanja biodiesel and its blends in a diesel engine. *Applied Energy*, 132, 453-460.
2. Bari, S. (2010). Effect of hydrogen addition on the performance of a diesel engine operated on biodiesel. *Energy Conversion and Management*, 51(10), 1945-1954.
3. Chauhan, B. S., Kumar, N., & Cho, H. M. (2016). A study on the performance and emission of a diesel engine fuelled with Jatropha biodiesel and hydrogen. *Fuel*, 182, 228-236.
4. Sharma, A., & Murugan, S. (2019). Combustion, performance and emission characteristics of a DI diesel engine fuelled with Kapok methyl ester and diesel blends. *Fuel*, 249, 45-54.