Performance Measures and Emission Analysis of Transesterified Palm Oil with a Blend of n-Butanol

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ABSTRACT

Biodiesel from vegetable oils have become alternative fuels for diesel engines and their implementation leads to marginal performance and decreased emissions. Transesterification process was carried out under room temperature to modify their efficiency and the performance of single cylinder compression ignition diesel engine using palm biodiesel as fuel was evaluated for its performance and emission characteristics. Varying proportions of palm biodiesel/diesel/n-butanol of 50%/30% /20% and 40%/30% /30% by volume were considered under different load conditions and the following parameters were measured- brake thermal efficiency, specific fuel consumption and brake mean effective pressure. PBD50D30B20 has lower brake thermal efficiency, mainly due to its high viscosity compared to diesel and PBD40D30B30. The specific fuel consumption and brake mean effective pressure showed positive results for PBD40F30B30 in comparison to PBD50D30D20 due to the presence of alcohol content. It has also been noted that the NOx emission have decreased over time when PBD40D30B30 is used. Smoke emissions showed decreasing values during the usage of PBD40D30B20 and hence it would be a forerunner for applications involving diesel engines.

KEY WORDS: Palm biodiesel, diesel, n-butanol, trasesterification, emission, performance.

1. INTRODUCTION

Consumption of energy is constantly increasing in spite of the validating measures that have been undertaken for the cause of meeting the needs (Puneet VermA, 2016). Fossil fuels are the most frequently used fuels for running machinery and automobiles (Senthilkumar, 2015; Mohsen Ghazikhania, 2013; Imtenana, 2014). Research has been focused on delivering the fuel that would be adaptable to the existing engine and that would meet the criteria regarding renewability and reliability of use (Rizalman Mamat, 2013; Yathish, 2013; Veeraragavan, 2013). Requirements that are fulfilled for the mentioned criteria forms the basis of a successful fuel replacement by biodiesel fuel. Over the last decade biodiesel has become the most common renewable liquid fuel due to its readiness to meet the existing requirements of the previously mentioned criteria (Bibin, 2015). The use of biodiesel does not require any type of engine modifications or modifications of the fuel injection system when they are mixed according to the ASTM standards (Mardhiana Binti Ismaila, 2015). The first use of vegetable oil in a compression ignition engine was first demonstrated by Rudolph diesel using peanut oil in his diesel engine. Later with the availability of cheap petroleum, crude oil fractions were refined to serve as diesel, a fuel for CI engines. In this research article, palm oil undergoes transesterification with the help of potassium hydroxide catalyst and methanol as the dominant alcohol content.

2. EXPERIMENTAL SETUP AND PROCEDURE

Transesterification process: The transesterification process involves the chemical reaction of the conversion of vegetable oil to methyl ester. Palm oil undergoes transesterification using Methanol and with a help of Potassium hydroxide as a catalyst. A mixture of 750 ml of palm oil, 1L of methanol and 500 ml of potassium hydroxide was stirred for 24 hours at room temperature using a magnetic stirrer. After the stipulated period the mixture was transferred to a separating funnel where the glycerol was separated from the palm biodiesel. The separation process involved the addition of distilled water to the mixture and allowing it to settle down by forming two separable layers involving glycerol and palm biodiesel. Glycerol is then made to flow through the funnel and the upper layer was acquired for further blending. The process was repeated to get at least 2L of palm biodiesel for further blending.

Blending process: The palm biodiesel which was then separated from glycerol was transferred to another beaker where correct proportion of commercial diesel fuel and n-butanol was added. 500ml of palm biodiesel, 300ml of commercial diesel fuel and 200 ml of n-butanol was blended together at room temperature and the blend was named as sample A (or) PBD50D30B20. Another proportion of 400 ml of palm biodiesel, 300 ml of commercial diesel fuel and 300 ml of n-butanol was added to obtain sample B (or) PBD40D30B30. Both the samples were made to attain 1L and hence the latter names were given according to the percentage of blends. The variability in sample B when compared with sample A was that the palm biodiesel addition was decreased from 50 % to 40% and n-butanol was increased from 20% to 30%.

Testing process: The engine used is Kirloskar TAF1 single cylinder, naturally aspirated, four stroke, air cooled, 17:1 compression ratio, diesel engine, and the engine power is 4.2 kW at 1300 rpm. Initially the engine was made to run on 1L of commercial diesel fuel and the required readings were taken. After the engine was free of commercial diesel fuel, sample A was introduced and the readings were noted for gradual increase in the load from 0 to 12Kg.

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The engine was made to run on sample 2 and the readings were taken for every gradual increase in load. The engine exhausts NOx and smoke were measured with AVL-444 Di gas analyzer for every increase in load and the values are tabulated. The performance and emission characteristics were evaluated according to the readings.

3. RESULTS AND DISCUSSIONS

The effect of biodiesel blending ratio on the performance and emissions were investigated at the base commercial diesel fuel for engine load from 0 to 12 kg. Comparing the results, the blend ratio PBD40D30B30 showed an ideal balance between reduced emission and brake thermal efficiency.

Brake Thermal Efficiency: It is the denoted as the brake power of an engine as a function of the thermal input from the fuel. It has been incurred from **Figure.**1 that Brake Thermal Efficiency of the two samples PBD50D30B20 and PBD40D30B30 increases with increase in the load similar to the commercial diesel but only lesser efficient than the latter. Brake thermal efficiency for PBD50D30B20 is 26.2. By adding extra 10% of n-butanol and removing 10 % of palm biodiesel the brake thermal efficiency increases to 27.64. This is due to increased alcohol content during the combustion process.

Specific Fuel Consumption: It denotes the fuel efficiency of an engine with respect to thrust output or fuel consumption per unit of thrust. It has been noted from the Figure.2 that the specific fuel consumption of PBD50D30B20 is 5.66. When 10 % of n-butanol is added and 10 % of palm biodiesel is removed the SPC reduces to 5.4.This is due to more oxygen content in the mixture with a possible drop in density.

Brake mean effective pressure: BMEP is a function of temperature of the gases in the cylinder. To increase the temperature you need to burn more fuel, thus making more heat. Or another way is to make better use of the existing fuel. Torque is a function of BMEP and displacement only. HP is a function of torque and rpm. It is obvious in the Figure.3 that the brake mean effective pressure of PBD50D30B20 is 4.13 and it increases to 4.62 when 10 % of n-butanol is added. This is made possible due to more complete combustion and excess oxygen.

NO_x Emission: NO_x is a term for the mono-nitrogen oxides and they are formed whenever combustion occurs in the presence of nitrogen. The visible data on Figure.4 shows that when the percentage of alcohol increases in the palm biodiesel blend then there is a decreased emission of NO_x when the load is increased. 10 % of alcohol content shows exaggerated decrease in emission at base loads.

Smoke Emission: Smoke is a collection of airborne solid and liquid particulates emitted when a material undergoes combustion. The volume of smoke emitted by the commercial diesel and PBD50D30B20 as seen from Figure.5 are 73.66 % and 63.59% respectively. When 10% n-butanol is added to the mixture then the volume of smoke emitted decreases to about 59.11%.

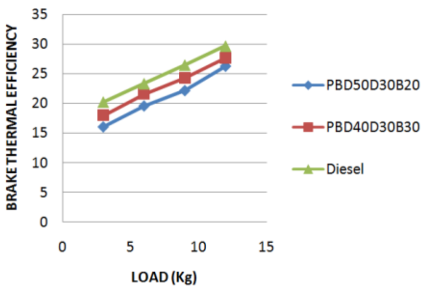

Figure.1.Brake thermal efficiency

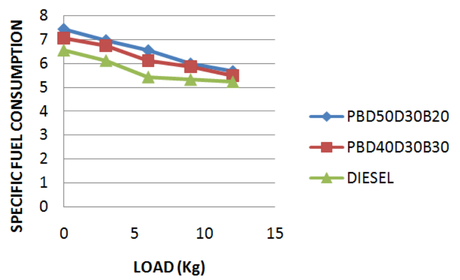

Figure.2.Specific fuel consumption

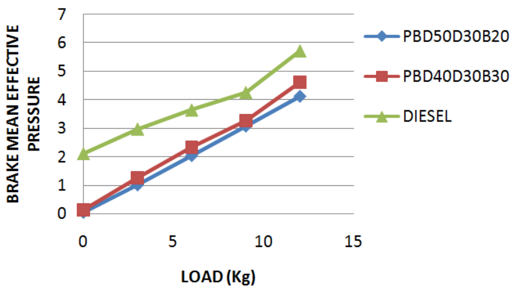

Figure.3. Brake mean effective pressure

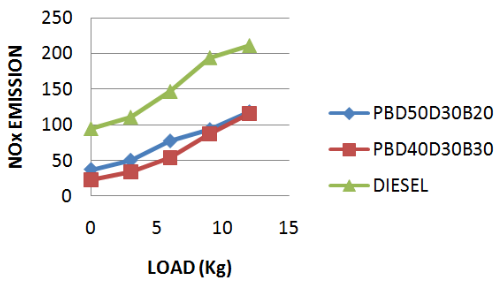

Figure.4.NOx Emission

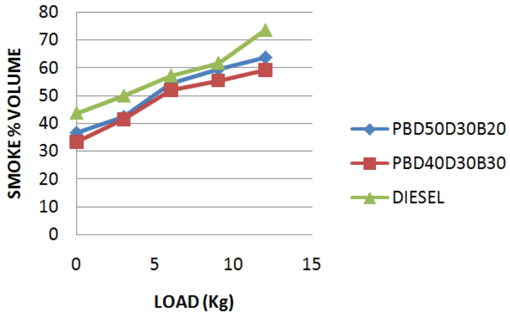

Figure.5.Smoke % volume

4. CONCLUSION

During the investigation various tests were carried out on a four stroke single cylinder diesel engine using diesel, palm biodiesel with additives (n-butanol) at different volume proportions. From the experiment, the following conclusions were made. The brake thermal efficiency of sample B (PBD40D30B30) is greater than that of sample A (PBD50D30B20) as the presence of alcohol content in the sample dilutes the density of the fuel. The specific fuel consumption of sample B (PBD40D30B30) shows similar characteristics when compared to commercial diesel fuel and exceeds the reliability over sample A (PBD50D30B20). Brake mean effective pressure of sample B (PBD40D30B30) is found to be better than sample A (PBD50D30B20). NO_X emissions of sample B (PBD40D30B30) are found to be lesser than that of commercial diesel fuel and sample A (PBD50D30B20). It is seen that NO_X emissions decreases with increase in percentage of additive to the palm biodiesel. Smoke emissions of sample B (PBD40D30B30) show greater reduction when compared to sample A (PBD50D30B20) and commercial diesel fuel due to the affinity of fuel to oxygen which was 10% extra in the sample B (PBD40D30B30).

REFERENCES

Bibin C, Bala Murugan V, Gopinath S, Dineshbabu N, Optimizing the Various Parameters for Biodiesel Production by Transesterification, International Journal Of Engineering Research & Technology, 4(2), 2015, 352-357.

Imtenana S, Masjukia HH, Varmana M, Arbaba MI, Sajjada H, Rizwanul Fattaha MI, Abedina MJ, Emission and performance improvement analysis of biodiesel-diesel blends with additives, Science Direct, Procedia Engineering, 90, 2014, 472-477.

Mardhiana Binti Ismaila, Ghazi Faisal Najmuldeena, Wan Mohd Hafizuddin Wan Yusufa, Exploring the Transesterification of Castor Oil to Produce Second Generation Biodiesel using a Novel Catalyst, International Journal of Engineering Research & Technology, 4(1), 2015, 125-129.

Mohsen Ghazikhania, Mohammad Hatamib CN, Behrouz Safaria, Experimental investigation of performance improving and emissions reducing In a two stroke SI engine by using ethanol additives, Propulsion and Power Research, 2 (4), 2013, 276-283.

Puneet Verma M.P, Sharma, Gaurav Dwivedi, Evaluation and enhancement of cold flow properties of palm oil and biodiesel, Science Direct, Energy reports, 2, 2016, 8-13.

Rizalman Mamat, Ahmad Fitri Yusop, Rafidah Rahim, Amir Aziz and Liyana Amer Shah, Fuel Physical Characteristics of Biodiesel Blend Fuels with Alcohol as Additives, Science Direct, Procedia Engineering, 53, 2013, 701-706.

Senthilkumar S, Sivakumar G, Siddarth Manoharan, Investigation of palm methyl-ester bio-diesel with additive on performance and emission characteristics of a diesel engine under 8-mode testing cycle, Alexandria Engineering Journal, 54, 2015, 423-428.

Veeraragavan V, Experimental Investigation of Castrol oil Methyl Esters as Biodiesel on Compression Ignition Engine, International Journal of Engineering Research & Technology, 2(2), 2013, 445-449.

Yathish KV, Omkaresh BR, Suresh R, Biodiesel Production From Custard Apple Seed (Annona Squamosa) Oil And Its Characteristics Study, International Journal Of Engineering Research & Technology, 2(5), 2013, 1142-1148.