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RESEARCH ARTICLE

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AN EXPERIMENTAL STUDY ON THE PERFORMANCE AND EMISSION CHARACTERISTICS OF SINGLE CYLINDER COMPRESSED IGNITION ENGINE USING EMULSIFIED PALM BIODIESEL.

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ABSTRACT

In the present research, an experiment is designed and conducted to investigate the effect of emulsified palm biodiesel i.e. W/PB originating from non edible Palm diesel fuel (PB) on the combustion performance and emission characteristics of a direct injection C.I. engine under varying engine loads (0–100%) and constant engine speed (1500 rpm). Three types of W/PB are tested, which consist of different water percentages (5%, 10% and 15%), with constant 1% of surfactant and labeled as EPB5, EPB10 and EPB15, respectively. The specific fuel consumption (SFC) of the engine when using each type of W/PB is found to be reduced overall. This is observed when the total amount of Palm Biodiesel fuel in the emulsion is compared with that of conventional diesel D. In addition, it produces the lowest exhaust gas temperature (EGT) effects in almost every load compared to conventional diesel D and other W/PB. NOx emission was found to be highly reduced for all types of W/PB. The carbon monoxide (CO) emissions increase or are comparable as compared to conventional diesel D at low load but decreases under higher engine loads, respectively. Overall, it is observed that the formation of W/PB from low-grade conventional diesel is an appropriate alternative fuel method that can bring about greener exhaust emissions and fuel savings without deteriorating engine performance or any major engine modification.

KEY WORDS: Conventional diesel fuel (D), Combustion performance, Exhaust gas emissions, water in biodiesel emulsion (W/PB), Compressed Ignition engine (C.I. engine).

I. INTRODUCTION

Currently Energy consumption is rising everywhere in the world. At the same time, natural resources are decreasing and pollutant emissions are becoming a real threat for the ecosystem equilibrium. This lessening fossil fuel resource, coupled with the steady rise in energy consumption, has urged research interest in field of alternative and renewable energy sources. In this context, the European Union is promoting the use of alternative renewable resources and a new directive has been implemented for the promotion of the use of bio fuels or other renewable fuels for transport, by replacing diesel and petrol up to 2% by 2005 and 5.75% by 2010 [1]. Developing countries such as India and China have experienced a significant

increase in energy demand in recent. Moreover, the persistent hike in global prices of crude oil is becoming the major issue in every country which is not good. This exacerbates the situation in the form of diminishing production rate, the instabilities in the petroleum production and the processing costs such as; desulphurization in order to meet stringent emission norms etc [2]. This, unavoidably, reflects an adverse impact on the local economy of many countries, especially the oil importing countries, by posing a severe burden on their foreign exchange [3]. Alternative fuels including biodiesels as well as the use of fuel additives are among recent methodologies that aim at better utilization of low calorific fuels and/or improving engine performance while meeting environmental regulations. The mixing of low calorific fuels with light fuels and/or the use fuel emulsions (fuel mixed with water) are currently considered as promising ways to realize improved fuel economics and usage of low grade fuels. The use of Water-in-Fuel Emulsion (WFE) has been stated as the most universal and effective method that enable simultaneous reduction of the engine smoke level and nitrogen oxides (NOx) without the necessity for engine modifications [4].

II.EMULSIONS

An emulsion is mixture of two liquids, in which one is present in droplets form of macroscopic or ultramicroscopic size, dispersed throughout the other remaining one. Also an emulsion is a thermodynamically unstable system consisting of at least two immiscible liquid phases one of which is dispersed as globules in the other liquid phase stabilized by a third substance called emulsifying agent. Emulsions are made by methods from the constituents spontaneously or by a mechanical technique. Water in Biodiesel emulsion comes under the category of water in oil emulsion. The surfactant that has to be used should have an HLB value in the range of 7 to 11. One surfactant with this value can be used otherwise mixed surfactant can be used. In the latter case the two surfactants should be chosen carefully so that one is hydrophilic and other is lipophilic [5].

III. MATERIALS AND METHOD

Here the Palm biodiesel blend PB20 (20% Palm Biodiesel + 80% Diesel) is taken/selected for the experimental purpose. To make emulsion these material and Components required: Mechanical agitator, diesel, water, Palm biodiesel, surfactant, burette, syringe and test tubes.

1. The test tubes, new syringe and container were washed thoroughly and cleaned to dry.
2. Diesel was measured in the dimensioned container in required volume and poured into other scaled container. Now calculated volume of each surfactant (Span 80) as per requirement were measured in the syringe and poured into the container. Same done for water but by small cylindrical container.
3. Now the mixture filled container is placed under the mechanical REMO agitator and the mixture is thoroughly mixed for about 10 - 15 minutes.
4. Thus the PB20W5, PB20W10 and PB20W15 emulsion were prepared and were checked for experiment.

IV.PREPARATION OF TEST FUEL BLENDS

Various trials were carried out before obtaining a stable emulsion:

Table 1 - Procedure for Fuel Preparation.

Fuel	Calorific Value(CV) (KJ/Kg)	Kinematic Viscosity(cSt)	Density(g/cc)
Diesel	41907	2.8	0.814
PB20W5	40207	4.6	0.826
PB20W10	39272	5.4	0.831
PB20W15	37382	6.5	0.839

Table 2 - Properties of Prepared fuels.

Make	Procedure
Trail 1	94 % PB20 + 5% water + 1 % Span 80
Trail 2	89 % PB20 + 10% water + 1 % Span 80
Trail 3	84 % PB20 + 15% water + 1 % Span 80

V. EXPERIMENTATION

Single cylinder, four stroke, water cooled, direct injection CI engine is used for experimental purpose. The engine Performance analysis has included the following features: brake specific fuel consumption and brake thermal efficiency and finally the temperature of the outlet exhaust gas. The specifications of the CI Engine are listed in Table 3.1 and the experimental set up is shown in Figure.

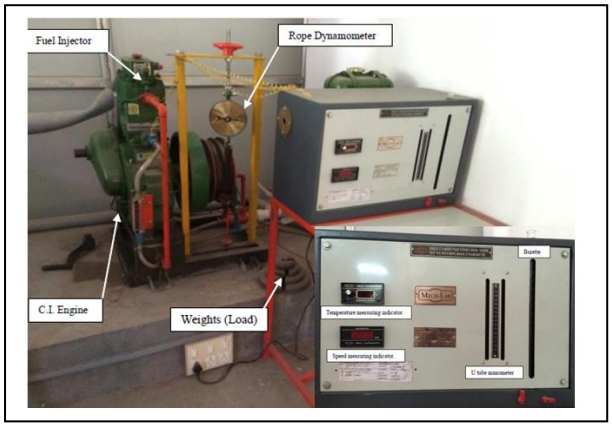

Figure 3.1 Engine test rig

Table 3 - Engine Specification

Make & Model	TYPE OF EMULSION
General Details	Four stroke, Single cylinder, Vertical, Compressed Ignition, Water Cooled, Direct Injection
Make	Kirloskar
Bore	87.5
Stroke	110 mm
Compression ratio	16.5:1
BMEP at 1500 rpm	5.42Bar
Rated output	3.7 kW at Rated speed of 1500 rpm
Dynamometer	Rope type, water-cooled with loading unit

Experimental procedure

Experiments are carried out at constant engine speed of 1500 RPM and at different load variations. Emulsion is varied by changing water content in fuel. Starting from 5%, 10%, 15% Water content variation observations are taken for ideal condition i.e. PB20W5, PB20W10 and PB20W15 emulsion. Observations are taken at time when exhaust gas temperature remains steady. Various performance and emission parameters are measured at each vary condition and test fuel is mentioned below. Using measured data, brake thermal efficiency, brake specific energy consumption, Exhaust gas temperature is calculated for each test fuel including diesel.

VI. RESULTS AND DISCUSSIONS

Engine Performance Parameters

Figures shows variations in brake thermal efficiency, Brake specific fuel consumption and Exhaust gas temperature with brake power, Water in Biodiesel emulsion. The graphs are plotted to compare all considered fuels i.e. PB20W5, PB20W10, PB20W15 and conventional diesel.

Brake Thermal Efficiency

It is to be observed that the brake thermal efficiency of Emulsified biodiesel was less than that of diesel due to its lower calorific value. Emulsified fuels PB20W15 with 15% Water content and conventional diesel content exhibited lowest and highest BTE at all engine loads, respectively. This was because of the micro explosion phenomenon due to volatility difference between water and fuels which enhanced air fuel mixing during higher engine torque. The maximum value of BTE measured by PB20W5, PB20W10, PB20W15 and conventional diesel are 32.49 %, 31.50 %, 30.85 % and 35.16 %. PB20W5 is more comparable to conventional diesel and is 7% less than diesel.

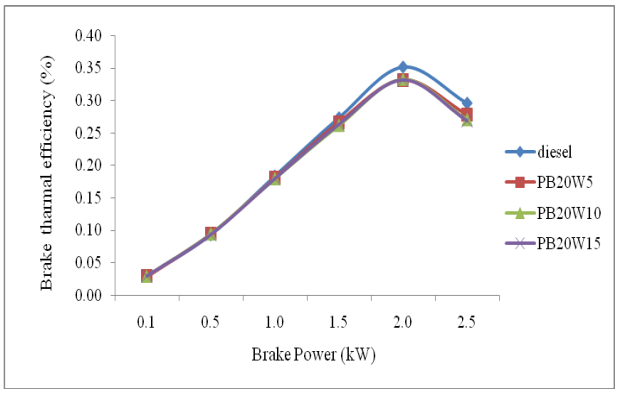

Figure 4.1 Variations in Brake Thermal Efficiency with Brake Power and Different water proportioned in emulsified Biodiesel Fuel

Brake Specific Energy Consumption

It is observed that PB20W5, PB20W10 and PB20W15 emulsion of biodiesel has higher specific fuel consumption as compared to diesel fuel and emulsion containing 15% water content PB20W15 was having highest BSEC values among the fuel tested. This is due to lower energy content of

biodiesel emulsion which has resulted in more fuel consumptions. When the percentage of water in the emulsion fuel increased, BSEC decreased. This might be attributed to the formation of finer spray due to rapid evaporation of water, longer ignition delay resulting in more fuel burning in premixed combustion and suppression of thermal dissociation due to lower cylinder average temperature.

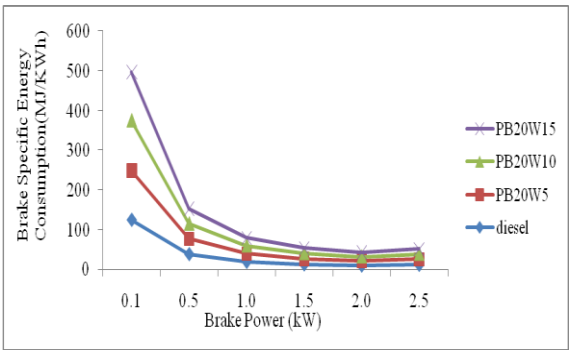

Figure 4.2 Variations in Brake Specific Energy Consumption with Brake Power and Different water proportioned in emulsified Biodiesel Fuel

Minimum BSEC for diesel, PB20W5, PB20W10 and PB20W15 fuels are 10.23 MJ/kWh, 10.85 MJ/kWh, 10.81 MJ/kWh and 10.86MJ/kWh respectively. The evaporation and additional mass of water caused the cylinder average temperature to lower with increasing water amount in the emulsified biodiesel fuel.

Exhaust Gas Temperature

The variations of exhaust gas temperature (EGT) with brake power for all test fuels shown in Fig. 4.

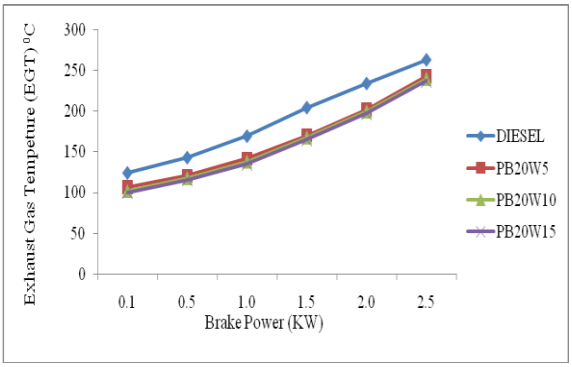

Figure 4.3 Variations in Exhaust Gas Temperature with Brake Power and Different water proportioned in emulsified Biodiesel Fuel

The exhaust gas temperature increases with increase in load because more fuel is burnt at higher loads to fulfill the power requirement. The EGT of biodiesel emulsions are detected to be lesser than that of palm biodiesel. This decrement is because of the water content in the biodiesel emulsion gets vaporized during the combustion process and decrease the adiabatic flame temperature by absorbs the heat energy. This effect leads to lower EGT than those of biodiesel fuel. The exhaust gas temperatures for diesel and biodiesel emulsions i.e. PB20W5, PB20W10 and PB20W15 are 263.2°C, 243.32°C, 240.14°C and 238.1°C respectively at full load. The 20% emulsified biodiesel PB20W15 shows 9.9 % EGT reduction than in conventional diesel respectively at full load.

Engine Emission Parameters

Carbon Monoxide (CO)

It is to be observed that the CO emission in general was found to be decreased significantly with increase in water content in the fuel blends i.e. PB20W5, PB20W10 and PB20W15 at all engine load tested. Minimum emission of CO with diesel, PB20W5, PB20W10 and PB20W15 fuels are 0.0196 %/Vol., 0.0162 %/Vol., 0.0173 %/Vol. and 0.0184 %/Vol. respectively at brake power of 1.5 KW.

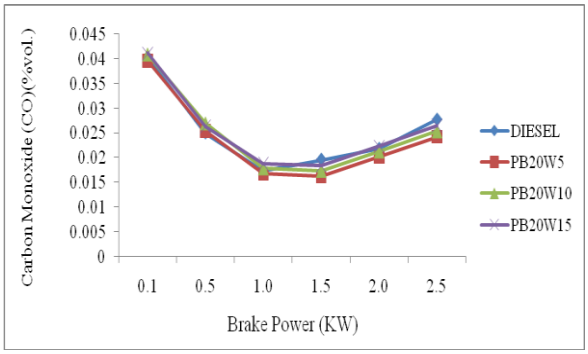

Figure 4.4 Variations in Carbon Monoxide Emission with Brake Power and Different water proportioned in emulsified Biodiesel Fuel

It was also observed that at lower engine loads, CO emissions for emulsified biodiesel were establish to be higher than conventional diesel but with supplementary increase in load up to 60%, due to Oxygen (O_2) availability and higher burning temperature of fuel developed and the CO emissions were found to be 15 to 30% less as compared to that conventional diesel. At 80%engine load, CO emissions for the biodiesel emulsified blends were observed to be 3 to 5% higher than the conventional diesel due to its lower air fuel ratio.

Hydrocarbon (HC)

It is to be observed that all the emulsified fuels tested i.e. PB20W5, PB20W10 and PB20W15 were observed to have low HC emission as compared to diesel at all considered engine loads. PB20W15 can be seen highest reduction fuel emulsion as compared to all fuels and specially Diesel. This is due to improvement of air fuel mixing due to phenomenon of micro explosion, which improves the combustion process and hence makes a reduction in HC emissions.

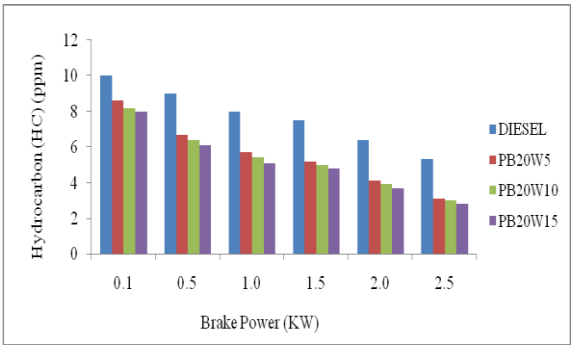

Figure 4.5 Variations in Carbon Hydrocarbon Emission with Brake Power and Different water proportioned in emulsified Biodiesel Fuel

Oxides of Nitrogen (NO_X)

It is to be observed that NOx emissions of emulsified fuels i.e. PB20W5, PB20W10 and PB20W15 were found to less than Diesel at all engine loads. The maximum reduction of these emulsions is found with values of 0.025 ppm, 0.024 ppm, 0.0218 and 0.0302 ppm over conventional diesel. This was because the lower flame temperature, as the presence of water in the emulsified fuel reduced the formation of NOx to considerable value. PB20W15 proves to be maximum reduction in all fuels. The reduction was found upto 20% against conventional diesel.

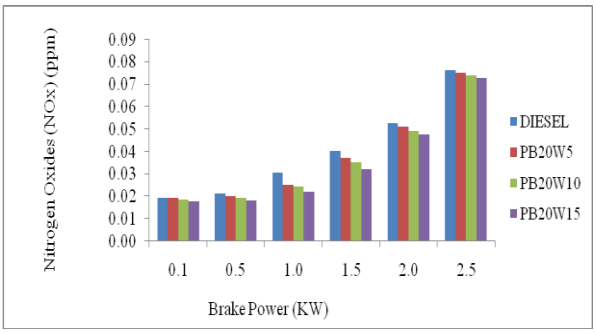

Figure 4.6 Variations in Oxides of Nitrogen Emission with Brake Power and Different water proportioned in emulsified Biodiesel Fuel

Additional reason might be due to the finely water droplets have got dispersed in the emulsion causing a 'heat sink' phenomenon. When this phenomenon occurs it results in absorbing the calorific value of the emulsions by the water contents of the inner phase partially, thereby decreasing the burning gas temperature i.e. inside the combustion chamber and thus preventing the generation of NOx emission.

Conclusion

The Conclusion were made from the results obtained after experimentations while running Single cylinder, four stroke, direct injection diesel engine fuelled with conventional diesel, blends of Palm bio-diesel, Water in diesel emulsions and Water in biodiesel emulsions. The results obtained were compared with reference diesel fuel. The results obtained were analyzed and following conclusion is made:

- Palm bio-diesel has comparative properties to diesel. Palm bio-diesel has 9 % lower energy content than diesel. Maximum power produced using highly blended Palm bio-diesel emulsion can be less compared to diesel because of lower calorific value and unsuitable for desired fuel properties.
- Maximum brake thermal efficiency using water in Biodiesel emulsions i.e. PB20W5, PB20W10 and PB20W15 fuels are 33.40%, 33.29% and 33.13% respectively at 2.0 Kw which as less as compared to conventional diesel having 35.10 %. In case of all reading of different water proportioned emulsified palm biodiesel, there is some small percentage reduction as compared to conventional diesel.
- Minimum BSEC for diesel is 10.23 MJ/kWh, and for PB20W5, PB20W10 and PB20W15 fuels 10.77 MJ/kWh, 10.81 MJ/kWh and 10.86 MJ/kWh respectively. All Palm Biodiesel emulsions are having higher BSEC as compared to diesel.
- Maximum EGT measure for diesel is 263 °C and PB20W5, PB20W10 and PB20W15 fuels are 243.32 °C, 240.14 °C and 237.10 °C which shows the decrease in exhaust gas temperature by 7.4%, 8.6% and 9.84%

respectively compared to diesel fuel at full load.

- Minimum emission of CO with conventional diesel is found to be 0.0277 %/Vol.. And CO emission with PB20W5, PB20W10 and PB20W15 fuels are 0.0242 %/Vol., 0.0253 %/Vol. and 0.0265 %/Vol. are lower as compared to diesel fuel at full load but was higher at low load conditions.
- Highest HC emissions measurement for diesel is 10 ppm respectively at no load. The prepared PB20W5, PB20W10 and PB20W15 fuels have value as 8.6 ppm, 8.2 ppm and 8 ppm, here HC emission is decreased by 14%, 18% and 20% as compared to diesel.
- At brake power of 1 Kw the maximum emission of NO_x with diesel is found to be 0.0302 ppm respectively. At the same brake power the values of PB20W5, PB20W10 and PB20W15 fuels have value 0.025 ppm, 0.024 ppm and 0.0218 ppm are lower as compared to diesel fuel. It can be seen that there is considerable reduction of 20% in all emulsified palm biodiesel fuels.

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