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Research Article

EXPERIMENTAL ANALYSIS OF DIESEL ENGINE USING ALGAE BIO-FUEL WITH DIETHYL ETHER AS ADDITIVES

KUBERAN J[1]* AND ALAGUMURTHI N[2]

[1]Research Scholar, Department of Mechanical Engineering, S.K.P Engineering College, Tiruvannamalai, India.

[2]Professor, Department of Mechanical Engineering, Pondicherry Engineering College, Pondicherry, India.

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ABSTRACT

India is the world's largest developing country, which has huge population and thus the number of vehicles has been increasing, the fact is that consume more power than generate. In our modern world fossil fuels cannot be able to full fill the demand and thus leads the cost of fossil fuel to increase. The fossil fuels emit more hydrocarbons and carbon monoxide and thus lead to the environmental pollution. This made the researchers to search for alternate fuels. The best alternate fuel which is identified so far is bio fuel. Bio fuels can be extracted in many forms and by many methods. All the method has its own merits and demerits. The bio fuel extracted from Spirulina micro algae which has high lipid content and high biomass productivity. Bio fuel has low performance characteristics and thus cannot be used directly in the commercial vehicles. The stability of bio fuel increased by adding 5% Diethyl Ether (DEE) as an additive with 10% Spirulina micro algae bio oil by keeping 90% diesel as base fuel. It increases the Brake thermal efficiency and reduces the specific fuel consumption (SFC) of the diesel engine and also improves the combustion characteristics of the fuel. The emissions such as hydro carbons (HC), carbon monoxide (CO) are also reduced.

INTRODUCTION

Increasing demand of fuel day by day its consumption and hazards cause serious intensive attention is required for this problem. Also an Improvement of fuel properties is essential for suppression of pollutant and optimization of engine performance. One way is use of additives. Oxygenated additives were conventionally recommended for gasoline. But now day's oxygenated additives are widely considered for diesel fuel. These additives can also be used in combination with biodiesel. There are number of additives are available for diesel fuel. On the basis of different experimental investigations by the researchers, this paper reviews about Di-ethyl Ether (DEE) as oxygenated additives mixed with diesel- bio-oil blends and compares its effect on performance and exhaust gas emission of compression ignition engine.

Micro Algae

Microalgae are currently the most promising source of bio fuels for total substitution of fossil fuels. Distinct benefits of microalgae compared to terrestrial feedstock include, their higher photosynthetic efficiencies, and higher productivity which can potentially produce substantially greater biomass yields per day and per unit cropping area. The numbers of studies that have evaluated the potential of using raw algal oil in an engine are insufficient to gain a full understanding of the likely performance of this fuel. The use of raw algal oil can overcome problems related with the use of expensive chemicals andprocedures during the transesterification reaction necessary to produce biodiesel.

Spirulina

Spirulina is a multicellular, filamentous

***Corresponding authors email: kkuberdr@gmail.com; alagumurthi@pec.edu**

cyanobacterium which can colonize environments that are unsuitable for many other organisms, forming populations in freshwater and brackish lakes and some marine environments, mainly alkaline saline lakes. The growth of *Spirulina* and the composition of the biomass produced depend on many factors, the most important of which are nutrient availability, temperature and light (Saifullah, *et al*., 2015; Sandip, *et al*., 2016). In addition, *Spirulina* requires relatively high pH values between 9.5 - 9.8, which effectively inhibits contamination by most algae in the culture (Fig. 1).

Extraction of oil from algae is costly and there are more disadvantages for the conventional methods. Extraction can be broadly categorized into three methods:

a) Mechanical Extraction

b) Chemical Extraction

c) Thermal Extraction

Pyrolysis

Pyrolysis is a thermal degradation process of biomass at optimum temperatures in the absence of oxygen. It involves the simultaneous change of chemical composition and physical phase and is irreversible. The algae biomass feed in to the reactor chamber and heated in the absence of oxygen. For this nitrogen gas is passed at 0.5 kg/cm^2.

In the absence of oxygen, the heat is used to break the chemical bonds by vaporizing many constituents of the biomass. Once vaporized the products can be cooled to form a liquid, this liquid can be used for fuel once the process is complete there are three major products produced: oil, charcoal and gas. Algae pyrolysis has many advantages, such as the ability to recover fuel without modification, and it has low viscosity, consequently the pyrolysis yield higher bio-fuel (Pugazhvadivu and Rajagopan, 2009; Akshatha, *et al*., 2014).

The reactor is placed on the floor with temperature indicator. The outlet of the reactor is directly connected to the condenser using a stainless-steel tube which can withstand high temperature. Another one inlet is connected to the reactor from the nitrogen cylinder. The condenser is firmly connected with help of alloy gasket. Counter flow condenser here selected. The flow of water is directed against the direction of pyrolysis gases.

The condensate drips into the gas liquid separator. The non-condensable gases rise to the neck of other tube and pass through the exhaust tube to gas burner. To measure the temperature outside the reactor the thermocouple is connected to the digital temperature indicator. Using setup button set the temperature level. The set up reach that temperature automatically off the supply. The temperature reduces the temperature of automatically power on (Fig. 2) and Table 1.

Blending of Bio-oil with Diesel

The 10% *Spirulina* algae oil taken at 350°C blended with 5% diethyl ether and 90% diesel, the proportionate ratios given as 1:9 The type of blending used here is splash mixtures where it represents as SP10DEED90 (Fig. 3) and Table 2 (Saranya, *et al*., 2015; Sankaran and Thiruneelagandan, 2015; Varsharani and Geeta, 2014).

Magnetic Stirrer with Hot Plate for Blending

The magnetic stirrer with hot plate is used for the purpose of blending with diesel, *spirulina* oil and additives of Di-ethyl Ether of the process.

ENGINE TEST PROCEDURE

The Experiment was conducted in a single cylinder four-stroke water-cooled diesel engine developing 4.4 kW at 1500 rpm. This engine was coupled to a dynamometer with control system. Time taken for fuel consumption was measured with the help of a digital stopwatch. The thermocouple in conjunction with a digital temperature indicator was used for measuring the exhaust gas temperature. An orifice meter attached with surge tank measures air consumption of an engine with the help of a U tube

Fig. 1 Wet and dry *Spirulina.*

Fig. 2 Pyrolysis setup.

Table 1. Oil extraction

S. No	Species	TEMP (°C)	Weight of Biomass in Kg	Time to Reach Max TEMP in hrs	Oil extracted in Kg
1	*Spirulina*	350	1	2.20	0.439

Table 2. Properties of blended bio-oil

Property	S10DEED90
Density (kg/m^3)	870
Calorific value (kJ/kg)	42700
Flash point (°C)	37-43
Fire Point (°C)	65-70
Viscosity (cP)	4.9

Fig. 3 Blending of bio-oil with additive.

manometer. Smoke intensity was measured with the help of a Bosch Smoke meter. Bosch Smoke meter usually consists of a piston type sampling pump and a smoke level measuring unit. Two separate sampling probes were used to receive sample exhaust gases from the engine for measuring emission and smoke intensity (Fig. 4).

RESULT AND DISCUSSION

Performance Characteristics

Brake thermal efficiency

The results of engine thermal efficiency using bio-oil blends are given in Fig 5. The thermal efficiency decreased marginally compared to diesel due to the lower heating value of bio-oil. Addition of 5% DEE to bio-oil blends, results indicate that the addition of DEE decrease the thermal efficiency marginally due to the lower heating value of DEE. The increase in brake power with reduced fuel consumption at higher loads helps to increase the BTE at higher loads. With the reduction in the fuel consumption and the effective burning of HC in the fuel the heat energy is obtained at its maximum from the fuel. The presence of oxygen in the DEE blend helps in complete combustion of the fuel raising the BTE (Fig. 5).

Specific fuel consumption

The SFC is higher for lower loads and it decreases in the mid loads and remains the same for peak loads. The SFC is lower for 5% DEE blend. This is due to better combustion of diesel fuel, which results in higher heat release. This increase in cylinder pressure, and results in higher power output. Hence, there is a considerable saving in the fuel. When the DEE composition is further increased, due to decrease in the calorific value of the fuel the SFC increases (Fig. 6).

EMISSION CHRACTERSTICS

Unburned Hydrocarbons

At full load HC emission in the exhaust has decreased with the increased volume of water-DEE solution. At full load there is a straight decrease of 20 ppm with DEE solution from 5%. At Zero loads on the engine this is due to the charge dilution because of low combustion temperatures (Fig. 7).

Carbon Monoxide

CO concentration in the exhaust Emission is

Fig. 4 Diesel engine setup.

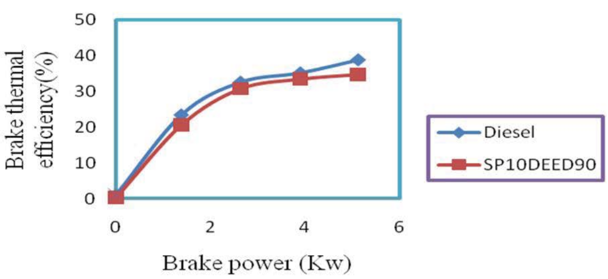

Fig. 5 Brake power vs. brake thermal efficiency.

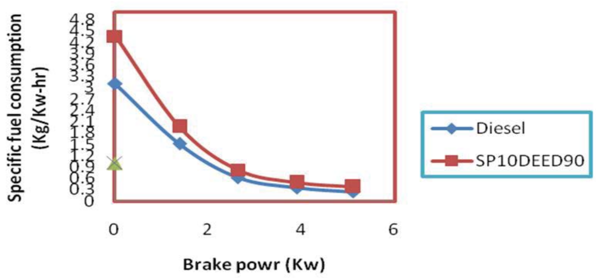

Fig. 6 Brake power vs. specific fuel consumption.

negligibly small when a homogeneous mixture is burned at stoichiometric air-fuel ratio mixture or on the lean side stoichiometric. With increasing DEE percentage in the blend, CO emission level is decreased for 5% DEE (Fig. 8).

Oxides of Nitrogen Emission

The NOx concentration varies linearly with the load of the engine. As the load increases, the overall fuel-air ratio increases, resulting in an increase in the average gas temperature in the combustion chamber, and hence NOx formation which is sensitive to temperature increase. When small quantities of additives like (Fig. 9),

CONCLUSION

The performance, combustion and emission characteristics of diesel and additive fuel (Diesel - Biofuel – DEE) were investigated on single cylinder four stroke diesel Engine . The brake thermal efficiency of diesel is 32.6% and additive bio fuel is 31.12%. Hence the brake thermal efficiency of additive biofuel is almost nearer to the diesel. The specific fuel consumption of diesel is 26.08% and additive Bio fuel is 29.18%. Hence the specific fuel consumption of the additive biofuel is closer to the diesel.

The additive bio fuel emissions of carbon monoxide, hydrocarbon, Oxides of nitrogen is less than the diesel because of the availability of oxygen content in the bio fuel which makes the combustion better.

Salient features of the conclusions that were obtained from comparison of experimental investigations for DEE blends is that it can be successfully added to the optimum selected percentage of DEE and optimized its blending ratio to overcome the poor ignition quality.

DEE is started adding the NOx content started reducing. Among the different cases of diethyl ether lower NOx levels were observed with 5% DEE additive.

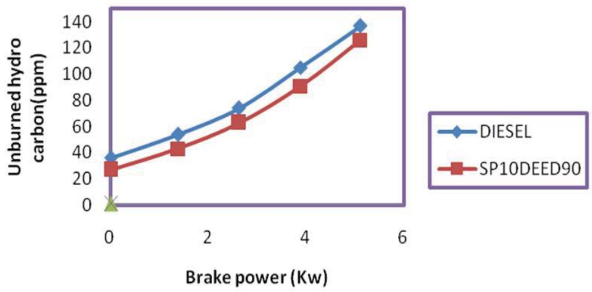

Fig. 7 Brake power vs. hydrocarbon.

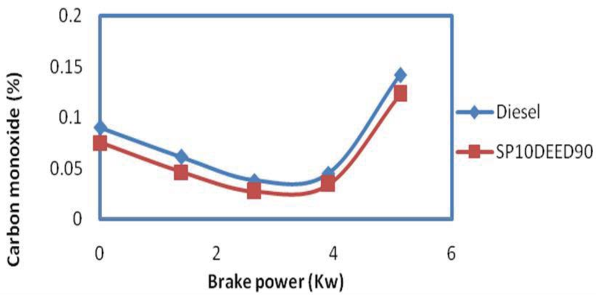

Fig. 8 Brake power vs. Co.

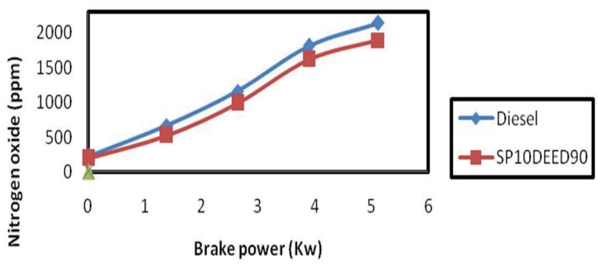

Fig. 9 Brake power vs. Nox.

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