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Experimental Investigation of Diesel Blend with Esterified Cotton Seed Oil on Cooper Diesel Engine

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Abstract

Petroleum based fuels play a vital role in rapid depletion of conventional energy sources along with increasing demand and also major contributors of air pollutants. There are wide varieties ofalternative fuels available;the past work revealed that uses ofvegetable oils for engines in place of diesel were investigated. However, several operational and durability problems of using straight vegetable oils in diesel engines due to their higher viscosity and low volatility.In present work, neat cotton seed oil is converted into their respective methyl esters through esterification process. Experiments were conducted using various blends with diesel and respective methyl ester in a cooper diesel engine.The results show that the maximum brake thermal efficiency and minimum specific fuel consumption were found for blends B20 and B40. There is an appreciable decrease in HC and CO2 emissions while the decrease in CO emission is marginal. However, emission of NOx is increased. It was observed that the combustion characteristics of the blends of esterified cotton seed oil with diesel followed closely with that of the base line diesel.

Keywords: Cotton seed oil, biodiesel, biodiesel blends, Cotton seed oil, alternative fuel.

Introduction

India is importing crude petroleum & petroleum products from Gulf countries. Indian scientists searched for an alternate to diesel fuel to preserve global environment and to withstand economic crisis. As far as India is concerned because of its vast agro-forestry base, fuels of bio-origin can be considered to be ideal alternative renewable fuels to run the internal combustion engines. Vegetable oils from plants both edible, non-edible and methyl esters (Bio-diesels) are used as alternate source for Diesel oil. Bio-diesel was found as the best alternate fuel, technically and environmentally acceptable, economically competitive and easily available.There are more than 350 oil bearing crops identified, among which only sunflower, soybean, cottonseed, rapeseed and peanut oils are considered as potential alternative fuels for Diesel engines.The oils that are extensively studied include Sunflower oil, Soya bean oil, Peanut oil, Rapeseed oil, Caster oil, Karanji, Palm oil, Neem oil etc., [1,2]. The long chain hydrocarbon structure, vegetable oils have good ignition characteristics, however they cause serious problems such as carbon deposits build up, poor durability, high density, high viscosity, lower calorific value, more molecular weight and poor combustion. These problems lead to poor thermal efficiency, while using vegetable oil in the diesel engine. These problems can be rectified by different methods which are used to reduce the viscosity of vegetable oils. These methods are: transesterification method, dilution method and cracking method [3]. The refining processes of vegetable oil gives better performance compared to crude vegetable oil [4,5,6,7]. Goering et al [8] studied the characteristic properties of eleven vegetable oils to determine which oils would be best suited for use as an alternative fuel source. Of the eleven oils tested, rapeseed, cottonseed, and soya bean oils had the most favourable fuel properties.

Chemically, esterification or refining process (also called alcoholysis) means taking a triglyceride a molecule or a complex fatty acid, neutralizing the free fatty acids, removing the glycerine and creating methyl esters. In order to prepare Methyl ester of Cotton seed oil (esterification) an experiment carried out in laboratory. For preparing Cotton seed oil 17% of methanol with 0.5% of sodium hydroxide on mass basis are taken and mixed thoroughly. One litre of neat cotton seed oil and 200ml methanol, 0.05 kg sodium hydroxide mixture are poured into an air tight flask. The mixture is stirred rigorously and heated at a constant temperature of 70°C for 60 minutes, and then it is allowed to cool over night without stirring in a separating funnel. Two layers are formed. The bottom layer consists of glycerol and the top layer is Ester. Glycerol is removed by opening the cock, leaving methyl ester in the funnel. Table 1 shows properties of Diesel, Cotton Seed Oil (CSO) and esterified CSO.

Table 1

Property	**Diesel**	**CSO**	**Esterified CSO**
Calorific Value (kJ/kg)	44000	39648	40,580
Flash Point (°C)	44	315	200
Kinematic Viscosity (at 30°C) (cSt)	4.59	49.6	5.8
Density (kg/m^3)	830	910	860
Cloud Point (°C)	-20 to 5	0 to 3.33	-2
Pour Point (°C)	-35 to -15	-12.22 to -6.67	-4
Cetane Number	49.6	41.8	52

Experiment Work

The Engine chosen to carry out experimentation is a single cylinder, 4-stroke, vertical, water cooled, self-governing Cooper Diesel Engine. It maintains constant 1800 rpm speed. This engine consumes less quantity of fuel due to single cylinder. Therefore this engine is selected for carrying experiments.

The engine has a rope brake type dynamometer to measure and to change its output. The engine has cross flow type calorimeter which measures temperature of inlet and outlet of exhaust gas and cooling water.The Infra-red gas analyser and smoke meter are used to measure the exhaust emissions.

The experiments are conducted for variable loads like 0, 3, 6, 9, 12, 15 and 18 kg at rated 1800 speed. Four blends of cotton seed oil such as 20% (B20), 40% (B40), 60% (B60), 80% (B80) and 100% (B100 - biodiesel) are used in this experimentation. The engine was sufficiently warmed up and stabilized before taking all the readings. The performance parameters such as Brake Thermal Efficiency (η_{bth}), Brake Specific Fuel Consumption (bsfc), Exhaust Gas Temperature (EGT), Indicated Thermal Efficiency (η_{ith}), Indicated Specific Fuel Consumption (isfc) and Emission parameters such as Carbon Monoxide (CO), Carbon Dioxide (CO_2), Hydro carbon (HC) and Smoke density are evaluated .These performance and emission parameters of biodiesel blends are compared to those of pure diesel.

Results and Discussion

Fig. 1 shows the plots of brake specific fuel consumption against load for the esterified CSO blends and diesel. It is observed that brake specific fuel consumption for blends ofesterified CSO in different proportions is less when compared with diesel. Variation of Brake Thermal Efficiency with Brake Power for Diesel and esterified CSO in the test engine is shown in Fig. 2. The variation of the exhaust gas temperature with load for different blends used is shown in Fig. 3. It is observed that exhaust gas temp is high for blends of esterifiedCSO when compared to diesel for the operating range. This is because with increase in load the temperature of combustion chamber increases as more fuel is burned and thus resulting in higher exhaust gas temperature.

The emission of HC decrease as the diesel is substituted by biodiesel. It is clear from Fig. 4, as increase biodiesel blend percentage, HC emission reduces. Cetane number of biodiesel is higher than diesel, due to this it exhibits a shorter delay period which contributes to better combustion of fuel resulting in low emission of HC.Other reason can be the oxygen molecules present on the structure of biodiesel which helps in complete combustion of the fuel and hence decrease in HC emission. Fig. 5 shows the concentration of CO with load and different blend. At all loads, engine emits less CO, when biodiesel is used as fuel as compare to diesel. The oxygen contain in the biodiesel provide oxygen for the complete combustion, hence reduction in the CO emission. Biodiesel mixtures CO emission was lower than that of diesel fuel. CO emitted by all biodiesel blends is lower than the ones for the corresponding diesel fuel case. This reduction in CO increases as the percentage of biodiesel in the blend increases. Increasing percentage of biodiesel in the blend, decrease the emission of CO_2 shown in Fig. 6. For B-20 biodiesel the CO_2 emission is comparable with diesel, and for B40 and B60 biodiesel the emission is less than diesel. This may be because of the fact that biodiesel is a low carbon fuel and also biodiesel has low elemental ratio of carbon to hydrogen as compare to diesel. This indicates complete combustion of fuel which is also indicated by the higher exhaust gas temperature. Biodiesel molecule contains carbon of biological nature. Every molecule of esterified

CSO contains 94.73% carbon of biological nature. Thus all CO_2 released by the burning of biodiesel has no adverse effect on greenhouse gas formation. However in case of diesel, all CO_2 releases are contributing to the formation of greenhouse effect. The advantage of biodiesel lie in the fact that CO_2 level is kept in the balance as the crops of biodiesel are readily absorbing the CO_2, thus biodiesel are CO_2 neutral. The smoke emission decreases consistently with the increasing amount of biodiesel in the blend as shown in Fig. 7. The reduction in smoke level at higher load may be due to better combustion at higher load and more biodiesel is required. Other reason may be the difference in chemical structure and presence of oxygen in the biodiesel.

Conclusion

Performances of the B20 and B40 blends of esterified cotton seed oil are higher than the diesel fuel because of higher Cetane number of esterified cotton seed oil but more content of esterified cotton seed oil is not comparable as diesel. At these blends, emissions are also lower except NO_x compared to pure diesel. The performance of the cottonseed oil methyl ester fuelled engine is comparable with diesel engine. Engine could be run without any modification and difficulty using cottonseed oil methyl ester blends. Now a day the cost of CSO is higher than that of diesel. However, if farmer themselves produces the esterified CSO than the cost of CSO can be reduced.

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Figures

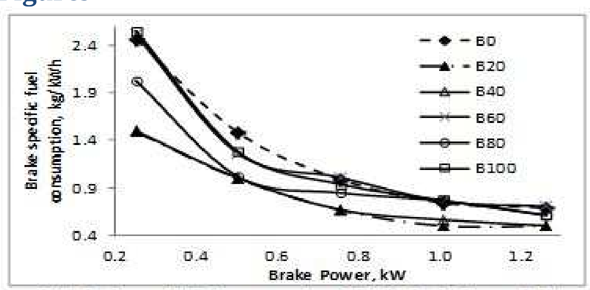

Fig 1 Brake specific fuel consumption (bsfc) Vs Brake Power (B.P.)

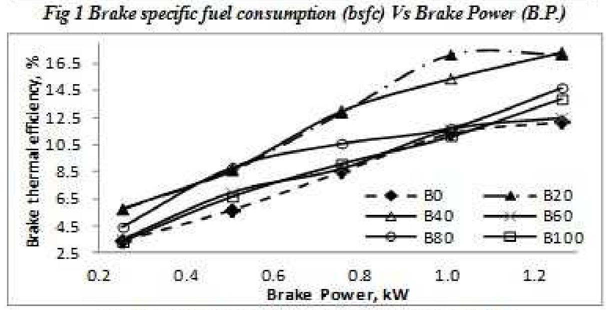

Fig 2 Brake Thermal efficiencyVs Brake Power (B.P.)

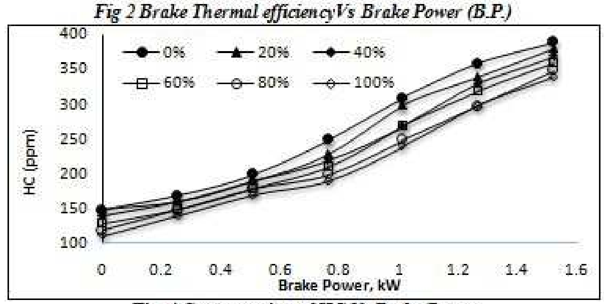

Fig. 4 Concentration of HC Vs Brake Power

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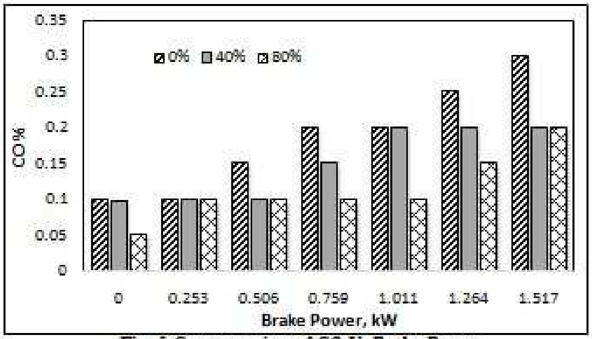

Fig. 5 Concentration of CO Vs Brake Power

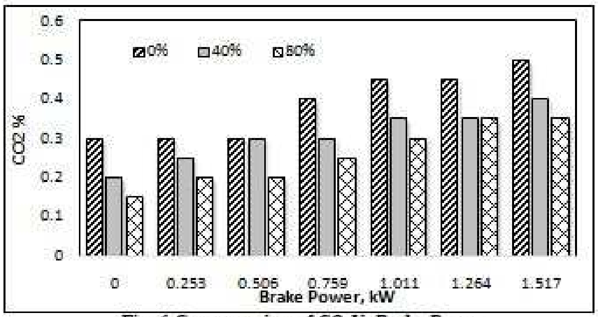

Fig. 6 Concentration of CO_2 Vs Brake Power

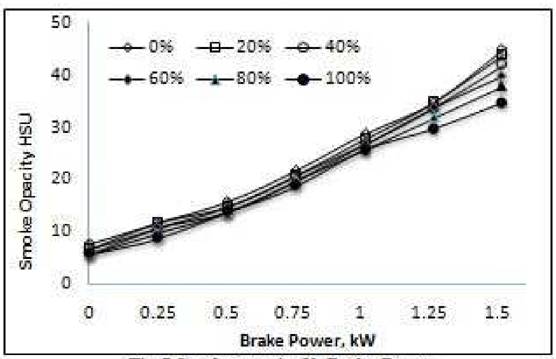

Fig.7 Smoke opacity Vs Brake Power