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Study of Performance Characteristics of Compression Ignition Engine Fuelled with Blends of Biodiesel from Used Cottonseed Oil

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ABSTRACT: Recent research on biodiesel is focused on the performance of a diesel engine when fuelled with biodiesel-diesel blends. Three combinations of used cotton seed oil biodiesel along with diesel are taken for the experimental analysis. Experiments are conducted using a single cylinder direct-injection diesel engine with different loads at a 3.5 kW diesel engine at three different load conditions i.e. no (0 kg), part (2-4 kg) and full load (6 kg) at 12 compression ratio. The engine characteristics of the three sets of used cotton seed biodiesel blends are compared. This paper investigates the scope of utilizing used cotton seed blends with diesel fuel for diesel engines. The blends of used cotton seed biodiesel are suitable alternative fuel for diesel in stationary/agricultural diesel engines. B10 blend of biodiesel has the highest performance characteristic value of brake power, brake thermal efficiency lowest value of brake specific fuel consumption and exhaust gas temperature. The objective of the present research was to explore technical feasibility of used cotton seed oil in direct injection C.I. engine without any substantial modifications in the engine design.

Keywords: Biodiesel;C.I. Engine; Performance Characteristics; Transesterification;Used Cotton Seed oil.

I. INTRODUCTION

Environmental concerns and limited amount of petroleum resources have caused interests in the development of alternative fuels for I.C. Engines. Petroleum resources are finite and therefore search for their alternative is continuing all over the world. The major energy demand is fulfilled by the use of conventional energy resources like coal, petroleum and natural gas. These sources are in the verge of getting extinct. The scarcity of conventional fossil fuels, growing emissions of combustion generated pollutants and their increasing costs will make biomass sources more attractive. The use of biodiesel is rapidly expanding around the world, making it imperative to fully understand the impacts of biodiesel on the diesel engine combustion process and pollutant formation. Bio fuels like ethanol and bio-diesel being environment friendly, will help us to conform to the stricter emission norms. Bio fuels are generally considered as offering many priorities, including sustainability, reduction of greenhouse gas emissions, regional development, social structure and agriculture and security of supply. In the developed countries, there is a growing trend towards employing modern technologies and efficient bio energy conversion using a range of bio fuels, which are becoming cost-wise competitive with fossil fuels.

The kinematic viscosity of vegetable oils is about an order of magnitude greater than that of conventional diesel fuel. High viscosity causes poor atomization of the fuel in the engine's combustion chambers and ultimately results in operational problems such as engine deposits. Biodiesel can be prepared mainly by four methods i.e. transesterification, pyrolysis, micro-emulsion technique or can be used by direct blending. To obtain biodiesel, the vegetable oil or animal fat is subjected to a chemical reaction termed transesterification. In that reaction, the vegetable oil or animal fat is reacted in the presence of a catalyst (usually a base) with an alcohol (usually methanol) to give the corresponding alkyl esters (or for methanol, the methyl esters) of the FA mixture that is found in the parent vegetable oil or animal fat. Biodiesel can be produced from a great variety of feedstocks. These feedstocks include most common vegetable oils (e.g., soybean, cottonseed, palm, peanut, rapeseed/canola, sunflower, safflower, coconut) and animal fats (usually tallow) as well as waste oils (e.g., used frying oils). The choice of feedstock depends largely on the geography.

Depending on the origin and quality of the feedstock, changes to the production process may be necessary. Biodiesel is miscible with diesel in all ratios. In many these blends with diesel are not biodiesel. Often blends with diesel are denoted by acronyms such as B20, which indicates a blend of 20% biodiesel with diesel.

Biodiesel from used cottonseed oil was produced by reacting it with methyl alcohol in the presence of KOH. An experimental study was also carried out to examine the fuel properties, performance characteristics of different blends of used cotton seed biodiesel in comparison to diesel fuel. Performance characteristics like brake power, brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature of biodiesel blended fuelled C.I. engine were evaluated and compared with that by fuelling diesel while the engine running at no, part and full load condition. The objectives of this experimental study are to assess performance characteristics of a diesel engine when tested with selected fuels and compared with diesel as a reference fuel.

II. MATERIALS AND METHOD

A. Materials

The used cotton seed oil used in this study was collected from various places in Patiala, Punjab, India. The biodiesel from the used cotton seed oil was extracted at Mechanical Engineering Research and Development Organization, Ludhiana, Punjab, India. The mineral diesel was bought from a local filling station in Patiala, Punjab, India.

Biodiesel was prepared from used cotton seed oil by alkali catalysed transesterification. KOH was used as the catalyst amounting 1.0% on mass basis and 20% methanol was treated with the used cottonseed oil. The water bath shaker was used for the base catalysed transesterification process.

B. Properties of Biodiesel

The properties of the mineral diesel and mineral biodiesel are tabulated in the table 1. These properties are compared with ASTM standards. The properties were tested at Mechanical Engineering Research and Development organization, Ludhiana, India & Thapar Research & Development centre, Patiala, India.

C. Experimental Setup

The engine tests were conducted on a single cylinder, direct injection water cooled compression ignition engine to evaluate the performance of a 3.5 kW diesel engine at three different load conditions i.e. no (0 kg), part (2-4 kg) and full load (6 kg) at 18 compression ratio. The engine has a hemispherical combustion chamber with overhead valves operated through push rods. Cooling of the engine was accomplished by circulating water through the jackets of the engine block and cylinder head. The specifications of the C.I. engine are summarized in table 2.

Table 1: Comparative properties of the diesel and biodiesel.

Property of B100 oil	ASTM Standard	Diesel	Biodiesel (from Used CSO)
Density (30^0C), kg/m^3	-	850	910
Kinematic viscosity, cSt	<5	2.049	3.6
FFA, %	<2.5	-	0.112
Carbon residue, %(m/m)	<0.05	0.0214	0.0112
Cloud point, ^{0}C	-3 to 12	<10	-3
Pour Point, ^{0}C	-15 to 10	-6	-8
Flash point, ^{0}C	>130	78	160
Fire point, ^{0}C	>53	83	165
Calorific value, KJ/kg	>33000	42000	40000

The experimental data generated were calculated and presented through appropriate graphs. Performance tests were conducted on various biodiesel blends in order to optimize the blend concentration for small term usage in CI engines. This test was aimed at optimizing the concentration of ester in the biodiesel blends to be used for one hour engine operation. To achieve this, three samples of used cottonseed biodiesel-diesel blends i.e. B10, B15 and B20 were prepared to be fuelled into variable compression diesel engine. The optimum blend was found out from the graph based on maximum thermal efficiency and other engine emission characteristics.

Table 2: Specifications of the engine.

Feature	Description
Make and Model	Kirloskar, TV1
Type of engine	4 stroke, Variable compression diesel engine
No. of cylinders	Single cylinder
Cooling media	Water cooled
Rated capacity	3.5 kW @ 1500 RPM
Cylinder diameter	87.5 mm
Stroke length	110 mm
Connecting rod length	234 mm
Compression ratio	12:1-18:1
Orifice diameter	20 mm
Dynamometer	Eddy current dynamometer
Dynamometer arm length	145 mm

III. RESULTS AND DISCUSSION

A. Brake Power (B.P.)

Fig. 1 illustrates the variation in brake power with the change in load. Brake power of the engine increases with increase in the load on the engine. Brake power is the function of calorific value and the torque applied. Diesel has more calorific value than the biodiesel, so diesel has the highest brake power among the different blends of biodiesel. Due to the more calorific value of B10 blend of biodiesel than B15 and B20, it produces the more brake power. It can also be seen that as we increase the load, torque increases and thus there is an increase in brake power with the load.

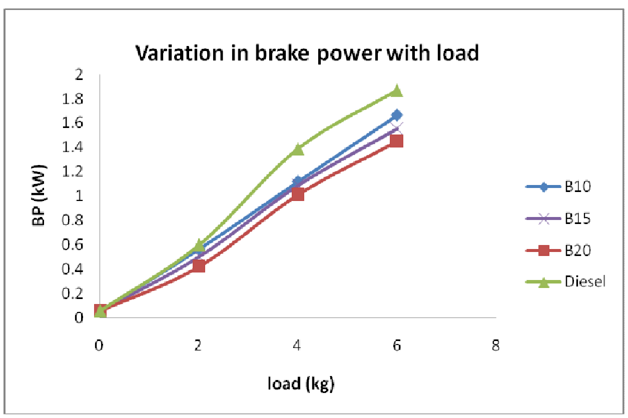

Fig. 1. Variation in brake power with change in load.

B. Brake Specific Fuel Consumption (BSFC)

Fig. 2 illustrates the variation in brake specific fuel consumption with the change in load. For all blends and diesel tested, BSFC decreased with increase in load. One possible explanation for this reduction is the higher percentage of increase in brake power with load as compared to fuel consumption. In case of biodiesel mixtures, the BSFC values were determined to be higher than that of neat diesel fuel. This trend was observed owing to the fact that biodiesel mixtures have a lower heating value than does neat diesel fuel, and thus more biodiesel mixtures were required for the maintenance of a constant power output. It is well known that brake specific fuel consumption is inversely proportional to the brake thermal efficiency. So diesel has the lowest brake specific fuel consumption. Among the three different blends of biodiesel, B10 has the lowest value of brake specific fuel consumption.

C. Brake Thermal Efficiency (BTE)

Fig. 3 illustrates the variation in brake thermal efficiency (BTE) with the change in load. In all cases, brake thermal efficiency increases with an increase in load. This can be attributed to reduction in heat loss and increase in power with increase in load. It is also observed that diesel exhibits slightly higher thermal efficiency at most of the loads than blends of cotton seed biodiesel.

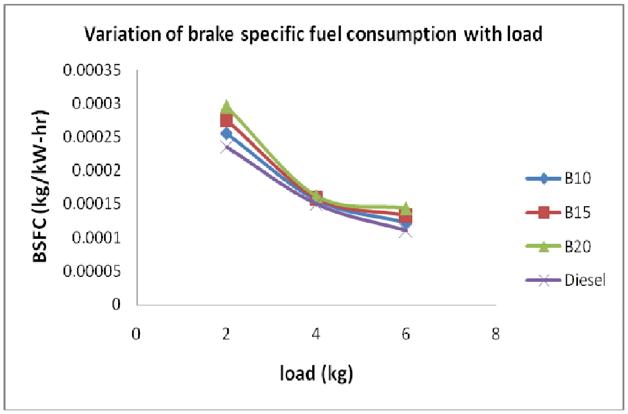

Fig. 2. Variation in brake specific fuel consumption with change in load.

The factors like lower heating values and higher viscosity of the biodiesel may affect the mixture formation process and hence result in slow combustion hence reducing the brake thermal efficiency. The molecules of bio-diesel (i.e. methyl ester of the oil) contain some amount of oxygen, which take part in the combustion process. Test results indicate that when the mass percent of fuel oxygen exceeds beyond a certain limit, the oxygen loses its positive influence on the fuel energy conversion efficiency in this particular engine. So the brake thermal efficiency of diesel is more than that of biodiesel blends. Among the three different blends of biodiesel, B10 has higher brake thermal efficiency than B15 and B20.

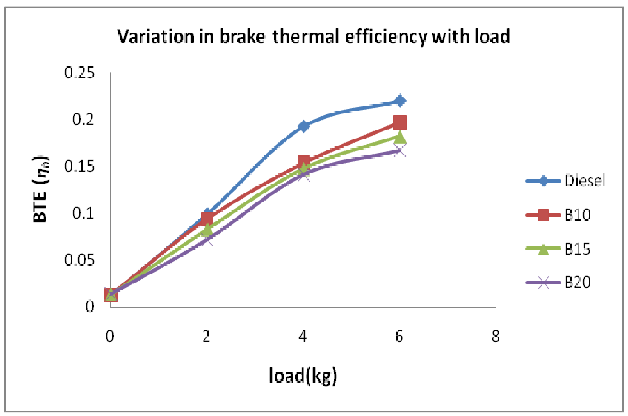

Fig. 3. Variation in brake thermal efficiency with change in load.

D. Exhaust Gas Temperature (EGT)

Fig. 4 illustrates the variation in exhaust gas temperature (EGT) with the change in load. The biodiesel contains some amount of oxygen molecules in the ester form. It is also taking part in the combustion process. When biodiesel concentration is increased, the exhaust gas temperature increases by a small value. Using different blends of biodiesel of cotton seed methyl ester, higher exhaust gas temperature is attained at full load, which is indicating more energy loss in this case. The exhaust gas temperature increases with increase in load. Diesel has the least exhaust gas temperature among B10, B15, B20 and D. The reason of EGT being more in the case of biodiesel blends is the presence of more oxygen atoms in the biodiesel. So, the exhaust gas temperature increases and it increases with increase in load. As the load on the engine increases, more fuel is burnt. So exhaust gas temperature increases continuously with rise in load.

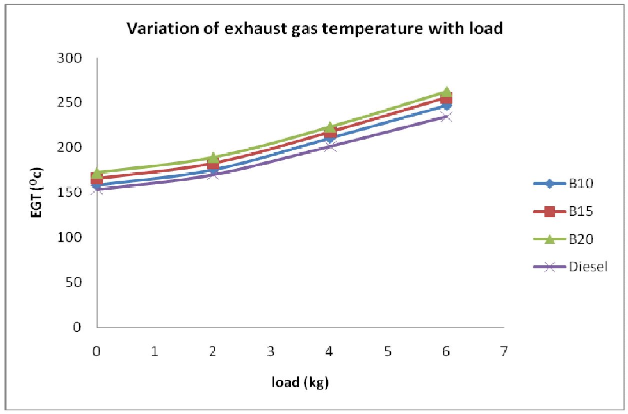

Fig. 4. Variation in exhaust gas temperature with change in load.

IV. CONCLUSIONS

The results indicated that the waste cotton seed oil biodiesel had the kinematic viscosity 75.69% more than that of diesel. The calorific value of waste cotton seed biodiesel is 4.76% less than that of mineral diesel. The graphical results show that diesel has better performance characteristics than biodiesel and biodiesel blends. Among the three different blends of biodiesel (B10, B15 and B20), B10 has the better performance characteristics than B15 and B20 blends of biodiesel when fuelled in a compression ignition engine.

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NOMENCLATURE

I.C. = Internal Combustion
C.I. = Compression Ignition
BP = Brake Power
BSFC = Brake Specific Fuel Consumption
BTE = Brake Thermal Efficiency
EGT = Exhaust Gas Temperature
B10 = 10% Biodiesel and 90% Diesel
B15 = 15% Biodiesel and 85% Diesel
B20 = 20% Biodiesel and 80% Diesel
D = 100% Diesel

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