Experimental Investigation of Performance Parameters of Four Stroke Single Cylinder Direct Injection Diesel Engine Operating On Rice Bran Oil & Rice Bran Oil Methyl Ester

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Abstract: The conventional fuel crisis arising and ecological concerns have directed to look for alternative fuels of bio-origin sources like edible and non-edible oils. That can be produced from forests, vegetable oil crops, and oil bearing biomass materials. The increasing oil prices rapidly in our life day by day. In environmental aspects, it is require to increase energy independence and produce employment are inspiring the countries around the whole world in support of biofuels research, invention and production. Biodiesel production is an important method which requires a sustained study and optimization process because of its advantageous ecological aspects and its renewable nature. Biodiesel fuel is clean burning diesel alternative and has several attractive characteristics including biodegradability, renewability, low emission and non toxic.

The main objectives of this study to produce biodiesel from Rice Bran Oil (RBO) by transesterification (alcoholysis) process and investigated the performance parameters of single cylinder four stroke diesel engines operating on Rice Bran Oil (RBO) & Rice Bran Oil Methyl Ester (RBOME) blends. Biodiesel is an alternative fuel to the broadly used petroleum-diesel fuel. Biodiesel can be produced by domestic and non-domestic sources such as Rice Bran Oil , Soybeans, Karanja, Cotton seeds, Coconuts, Jatropha, Rubber seed, Ratanjot Oil, Rapeseeds oil etc. and thus these reduces dependence on retreating petroleum fuel from distant sources. The main reason of the transesterification process is to decrease the viscosity of oil.

The brake specific energy consumption (BSEC) was increased as the blends were increased for constant engine speed and same engine brake load than that of petroleum-diesel. As the loads were increased the BSFC of diesel engine increased in comparison to diesel fuel. The BSFC of diesel engine were increased 9.1% and 5.69 % respectively for RBO 30 & RBOME 30 blends. The brake thermal efficiency (BTE) of diesel engine at constant speed of 1500 rpm and 12 kg brake load was decreased by 4.7% and 3.0% respectively when the engine fuelled with RBO 30 & RBOME 30 blends.

The performance parameters of diesel engine fuelled with RBO 10 & RBOME 10 were more closely to diesel fuel when the engine runs at 1500 rpm and for same brake load. The engine produce almost same brake power and brake specific fuel consumption (BSFC) is almost same for 10% blends of RBO and RBOME. The Engine tests demonstrated that rice bran oil methyl esters (RBOME) produced slightly higher brake thermal efficiency (BTE) than rice bran oil (RBO). The rice bran oil consumed slightly more fuel than methyl ester.

Keyword: *Diesel engine, RBO, RBOME, Performance*

I. Introduction

The lack of known petroleum fuels will create more attractive renewable energy sources [1, 2]. The biodiesels are derived from plant oils; they produce negligible net green house gas emissions [3]. Biodiesel can be directly used as a fuel in diesel engines without any modification of the existing design. Biodiesel can be considered as a promising alternative fuel for the diesel engines since its fuel characteristics are almost same as the petroleum diesel fuel [4]. Due to higher viscosity and lower heat content of biodiesel direct to the lower brake thermal efficiency of diesel engine. Higher viscosity causes poor fuel atomization during the injection of biodiesel fuel, resulted increasing the engine deposits and also fuel pump consumes more energy to pump the fuel which wears out the elements of fuel pump and injectors [5]. The use of raw vegetable oils in diesel engines without any engine modification results in poor engine performance and leads to wear out the engine components [6]. The investigations showed that esters of vegetable oils provide improved engine performance and minimize the emissions in compared to raw vegetable oils. It was investigated that the use of esterified vegetable oils as biofuel for diesel engine. The esterified sunflower oil 15% blend by volume with diesel fuel showed best combustion and performance in terms of total fuel consumption (FC), specific fuel consumption (SFC), brake thermal efficiency (BTE) and cylinder peak pressure etc. [7].

As a substitute fuel Mahua oil is the most suitable fuel for diesel engine. It was investigated that the Mahua oil could be easily substituted up to 20% blend in diesel without any major difference in power output, brake thermal efficiency (BTE) and brake specific fuel consumption (BSFC). The performance of diesel engine increased with Mahua oil blends by the increase in compression ratio from 16:1 to 20:1 [8]. The brake thermal efficiency (BTE), HC, CO, and soot concentration of diesel engine decreased and NOx emissions were slightly increased by addition of the rice bran oil methyl ester (RBOME) in diesel [9]. It is investigated that the BSFC of CI engine for karanja biodiesel and its blends with diesel are extremely closed to diesel fuel. At full engine load BSFC for neat biodiesel (B100) is increased by about 9% as compared to diesel [10, 11]. It is investigated that the brake specific energy consumption (BSEC) of waste frying methyl ester (WFOME) was increased by 8.0% and brake thermal efficiency (BTE) was decreased by 7.6% while the BSEC of WFOEE was increased by 10.3% and Brake thermal efficiency was decreased by 9.3% in comparison to diesel fuel at 50% engine brake load [12]. It was investigated that the brake thermal efficiency (BTE) of diesel engine decreased with the increase in blend percent in diesel. The values of BTE for diesel and karanja biodiesel are most closed to each other. When the neat biodiesel (B100) used in diesel engine at full engine load the brake thermal efficiency (BTE) is decreased by 2.92% as compared to diesel. The values of BTE for full engine load and at 18 Compression Ratio are recorded 28.65%, 28.75%, 29.32%, 30.05%, 30.5%, and 31.25% for B100, B80, B60, B40, B20, and diesel fuel respectively [13].

It was investigated that the brake specific energy consumption (BSEC) of diesel engine fuelled with 50 and 100% blends increased by 12.44 and 8.91% as compared to neat diesel fuel, whereas the average increase of the BSFC was observed to be 27.73% and 15.31%, respectively. The diesel fuel, B50 and B100 KOME showed an average increase of 0.85, 0.8 and 1.1% increased BSEC with the 10% EGR in comparison with the same fuel without EGR [14]. The thermal efficiencies recorded with COB, POB, and ROB was 28.04, 33.05, and 30.05%, respectively, at 100% load. Maximum brake thermal efficiency of 23.1% was observed with biodiesel (WCO-ME), which is 6% lower than that of diesel at 100% load condition [15]. COB showed less brake thermal efficiency (BTE) as compared to POB and ROB due to its higher viscosity and low volatility [16]. The maximum brake thermal efficiency (BTE) diesel engine is obtained 21.18% with KJB 20 while the lowest BTE is obtained 19.26% with KJB80 blends. KJB20 blends give the better results as compared to other biodiesel combinations [17]. It provides lubricating properties that can reduce engine wear and extend engine life [18].

II. Experimental Setup

The detail of technical specification of diesel engine is mention on table 1.

Table 1: Technical Specification CI Engine

Engine Parameters	Details
Make	Kirloskar Oil Engine, Pune
Model	SV1
Type	Vertical, Totally Enclosed, CI, Four Stroke Engine, Water Cooled
No. Of Cylinder:	ONE
Bore Size	87.5 mm
Stroke Length	110 mm
Cubic Capacity	662 CC
Compression Ratio	16.5:1
Engine RPM	1500
Rate of Output	5.88kW / 8 HP

Figure 1: Single Cylinder Four Stroke Diesel (CI) Engine Experimental Setup

III. Results & Discussion

3.1 Properties of Fuels

The detail of various fuel properties of RBO, RBOME, and diesel have taken out by the help of Indian Oil Corporation Limited, Bhopal, and the department of chemistry in University Institute of Technology, Bhopal. The various fuel properties are compared in detail in table 2.

Table 2: Compared the Physical properties of RBO, RBOME & Diesel

Property	RBO	RBOME	Diesel
Density at 50 °C (kg/m^3)	0.900	0.867	0.830
Specific Gravity	0.909	0.8825	0.836
Kinematic Viscosity at 40°C (cst)	41.7	4.72	2.636
Cloud Point (°C)	3.8	2.1	6.2
Pour Point (°C)	-12.0	3.0	2
Flash Point (°C) at 40°C	251	156	71
Fire Point (°C) at 40°C	173	164	78
Heat Content (kJ/kg)	36200	38830	41860

3.2 Performance of Diesel (CI) Engine

All experiments are performed at constant engine speed of 1500 RPM and variable engine brake load. The data recorded from the various experiments for evaluating the performance of single cylinder direct injection diesel engine.

The performance test of diesel engine fuelled with RBO & RBOME was resulted the increased brake specific fuel consumption (BSFC) as the engine brake loads were increased in comparison to diesel engine. The brake thermal efficiency (BTE) of diesel engine fuelled with RBO & RBOME decreased in comparison to diesel fuel when the percentage of blends increases. As the percentage of blends was increased the fuel consumptions (FC) of diesel engine slightly increased as the engine brake load and blends percentage were increased in comparison to diesel fuel. When diesel engine fuelled with RBO 30 and RBOME 30 blends engine consumed around 9.0% and 5.6% respectively more fuel at constant engine speed of 1500 rpm and 12 kg engine brake load as compared to conventional diesel. When the RBO 30 was used in diesel engine the fuel consumption has increased around 3-4% more than that of RBOME 30 blends for same load. For the same brake power the brake specific fuel consumption of diesel engine is slightly increased than that of petroleum-diesel. When rice bran oil blends are used in diesel engine, engine consumed slightly more energy in comparison to RBOME and conventional diesel for each blends and same engine brake load.

(1) Fuel Consumption

Figure 2 shows the variation in fuel consumption for diesel, RBO & RBOME when various blends are used in diesel engine. As the loads are increased the diesel engine consumed more fuel in comparison to diesel fuel. The fuel consumption (FC) of RBO 10 and RBOME 10 was increased around 3.4% and 1.5% than that of diesel while the fuel consumption (FC) of RBO 30 and RBOME 30 is increased by approximately 8.4% and 5.4% than that of diesel fuel when the engine runs at constant speed of 1500 rpm and 12 kg brake load. It is observed that at the same brake load engine consumed more fuel (RBO & RBOME) in comparison to conventional diesel fuel. During testing of diesel engine fuelled with rice bran oil engine consumed approximately 3.11% more fuel than that of the RBOME for same engine speed and 12 kg brake load. The fuel consumption of diesel engine for RBO 10 and RBOME 10 blends were slightly closed to diesel fuel.

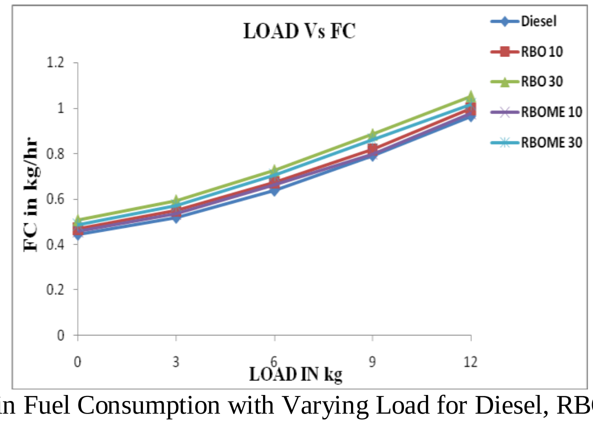

Figure 2: Variation in Fuel Consumption with Varying Load for Diesel, RBO & RBOME blends

(2) Brake Specific Fuel Consumption

Figure 3 shows the variation in brake specific fuel consumption (BSFC) with varying load for diesel, RBO & RBOME blends. It was resulted that the brake specific fuel consumption (BSFC) is higher than that of diesel when the RBO and RBOME blends were used in diesel engine. The BSFC of diesel engine was slightly decreased as the engine brake load increased. The BSFC of diesel engine fuelled with RBO 10 and RBOME 10 blends were 3.4% and 1.5% while the RBO 30 and RBOME 30 were around 8.4% & 5.4% respectively more brake specific fuel consumption than that of diesel fuel at 1500 rpm engine speed and 12 kg brake load. During testing of diesel engine RBO consumed 3.11% more brake specific fuel consumption than that of the RBOME when engine runs at constant speed of 1500 rpm and 12 kg brake load. The brake specific fuel consumption is an essential parameter by which compare the engines and determine the fuel efficiency of engines.

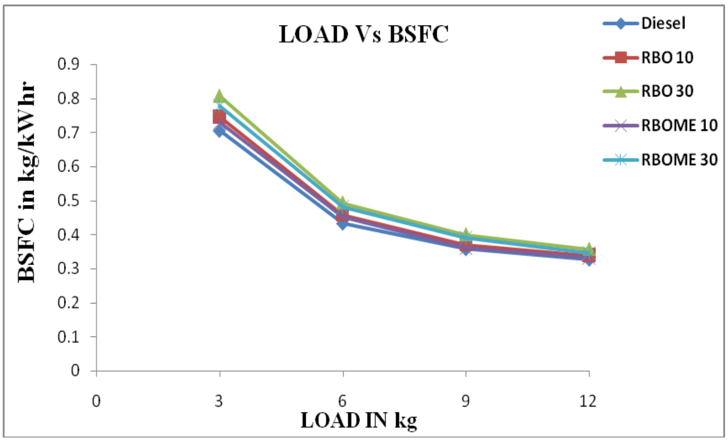

Figure 3: Variation in Brake Specific Fuel Consumption with Varying Load for Diesel, RBO & RBOME blends

(3) Brake Specific Energy Consumption

Figure 4 shows variation in brake specific energy consumption (BSEC) with varying load for diesel, RBO & RBOME blends. It was resulted that the BSEC of diesel engine has higher energy consumption that of diesel when the blends were used 10% and 30%. The brake energy consumption of diesel engine was more closely to RBO 10 and RBOME 1o blends. The BSEC of diesel engine was slightly decreased as the engine brake loads were increased. The BSEC of RBO 10 and RBOME 10 blends were increased approximately 2.11% and 0.70% while BSEC of diesel engine was increased approximately 4.7% and 3.1% when the blends were used RBO 30 & RBOME 30 respectively consumed more energy as compared to diesel fuel. During testing of diesel engine rice bran oil consumed about 1.54% more energy than that of the RBOME when engine runs at constant speed of 1500 rpm and 12 kg engine load.

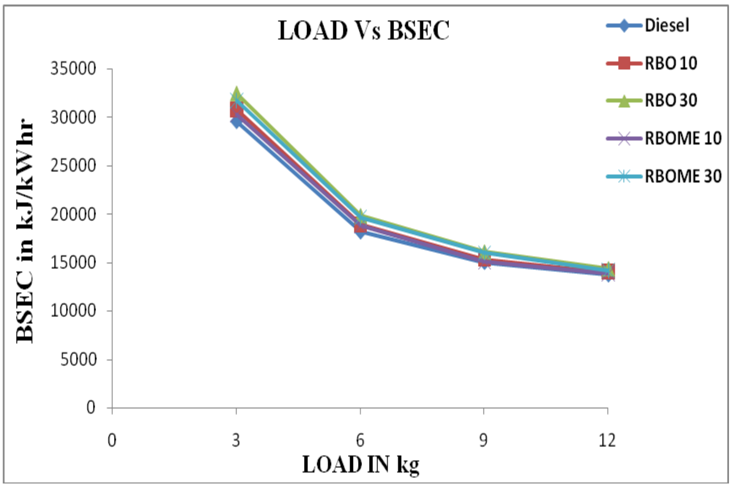

Figure 4: Variation in Brake Specific Energy Consumption with Varying Load for Diesel, RBO & RBOME blends

(4) Brake Thermal Efficiency

Figure 11 shows the variation in the brake thermal efficiency (BTE) of diesel engine fuelled with diesel, RBO and RBOME blends at various load. The brake thermal efficiency (BTE) of RBO and RBOME is decreased as the blends were increased. The brake thermal efficiency (BTE) of diesel engine used with RBO 10 & RBOME 10 blends were slightly closed to petroleum-diesel. The brake thermal efficiency of RBO 10 and RBOME 10 is less around 2.0% and 0.7% respectively than that of petroleum-diesel while the brake thermal efficiency of RBO 30 and RBOME 30 were less around 4.5% and 3.0% respectively in comparison to diesel fuel at 1500 rpm constant engine speed and 12 kg brake load. It is observed that the brake thermal efficiency of RBO 10 was decreased by 1.4% in comparison to RBOME 10 and in similar way the brake thermal efficiency of RBO 30 blends were decreased by 1.5% as compared to RBOME 30 blends.

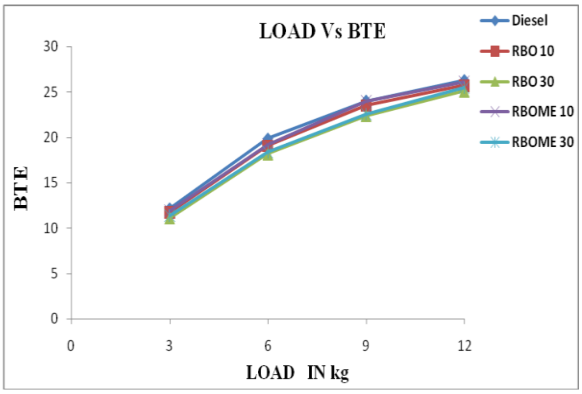

Figure 5: Variation in Brake Thermal Efficiency with Varying Load for Diesel, RBO & RBOME blends

IV. Conclusion

The specific gravity and flash point of RBO & RBOME are higher as compared to diesel fuel. It is concluded that the use of RBO & RBOME blends are slightly increases the brake specific fuel consumption (BSFC) as compared to diesel fuel for constant engine speed and same brake load. It was concluded that the brake thermal efficiency of diesel engine fuelled with RBO 10 & RBOME 10 blends were more closely to conventional diesel fuel. The maximum brake thermal efficiency of diesel engine was observed approximately 25.72% and 26.08% for RBO 10 and RBOME 10 blends. The BSFC of the RBO and RBOME blends were higher than that of the diesel fuel. When 30% RBO and RBOME are used in diesel engine RBO consumed 3.11% more fuel in comparison to RBOME. It is concluded that the performance test of diesel engine more closed to RBO 10 and RBOME 10 blends.

It is concluded that both fuels (RBO & RBOME) are suitable alternatives for diesel engine. Biodiesel obtained from rice bran oil can be used as a substitute fuel for conventional diesel fuel in future.

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