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Performance and Combustion Characteristics of Rice Bran Methyl Ester oil With Different Combustion Chambers by Varying Injection Pressure

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Abstract

Biodiesel crops such as Jatropha and Pongamia are being grown exclusively for biodiesel production. An alternative approach is to grow a food crop and use the waste material for biodiesel. Crude rice bran oil (RBO) is unpurified non-edible vegetable oil, which is available in huge quantities in rice enlightening countries the research in this area to utilize as a replacement for mineral Diesel in not much.. Crude rice bran was obtained from solvent extraction process by using n-hexane. Presence of long carbon linear chain gives excellent solubility in diesel. The calorific value (CV) of RBMEO is high and is closer to diesel. The corrosiveness of it also very mild due to nature of phenolic compounds present in it. Higher viscosity is the only drawback of every vegetable oil and this can be lowered while blending with diesel and ethanol if necessary. From these studies, the RBMEO biodiesel have the properties much closer to the conventional diesel and which can be used as a biodiesel in addition with diesel fuel. The goal of this study is to bring the alternative usage of RBMEO biodiesel to the limelight and to mitigate the serious problems posed by the depleting petroleum reserves. This work precedes the RBMEO (B100) biodiesel performance by different combustion chambers like hemisphere (base), toroidal and shallow depth shape pistons, comparison with petroleum diesel processes at constant speed and by varying injection pressure from 180-240bar with the intervals of 20bar, as well as environmental impact and controls of the liquid as petrochemical feedstock.

Keywords: Rice bran oil (RBO), combustion chambers and Rice Bran Methyl Ester Oil (RBMEO).

INTRODUCTION

India is the second largest producer of rice in the world, next to China, with the potential to produce about 1 million tonnes of rice bran oil per annum. Rice bran is a low value co-product of rice milling, which contains approximately 15–23% oil. This non-edible oil remains mostly underutilized. A huge quantity of rice bran is produced (approximately 8% w/w of paddy), which is an agricultural waste. It has significant potential as an alternative low cost feedstock for biodiesel production. Therefore, in this study, the use of rice bran oil is investigated for the production of biodiesel.

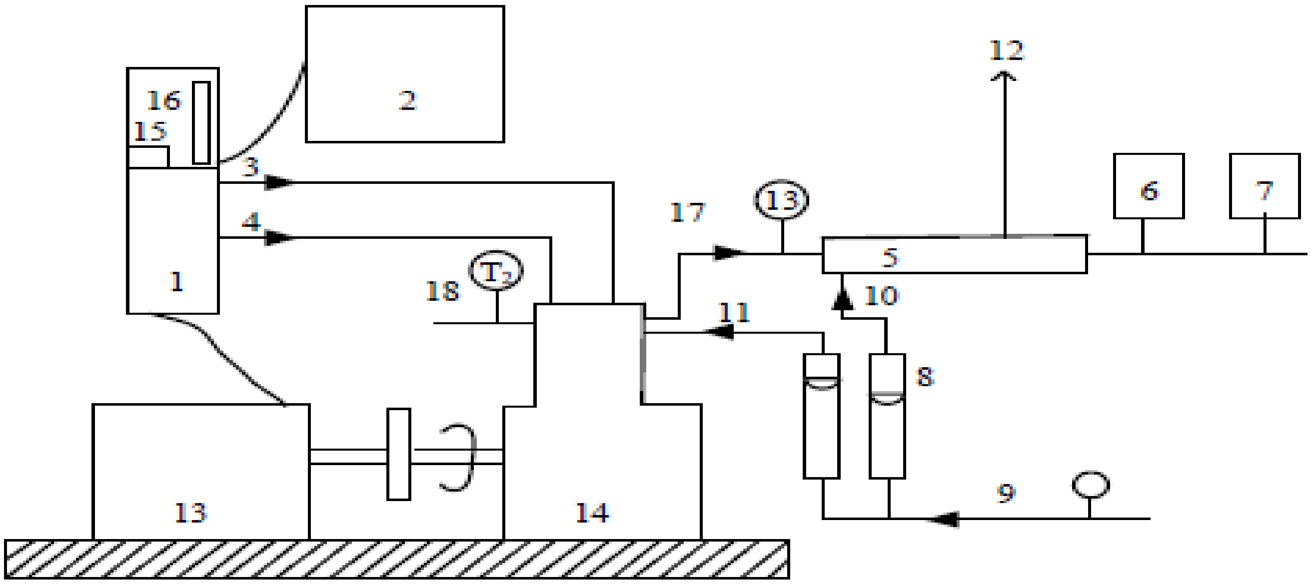
Diesel fuels have an important role in the industrial economy of any country. The high energy demand in the industrialized world and widespread use of fossil fuels is leading to fast depletion of fossil fuel resources as well as environmental degradation. The world petroleum reserves are so unevenly distributed that many regions have to depend on others for their fuel requirements. The degrading air quality due to emissions is the main adverse effect of petroleum based fuels. All these factors necessitate continued search and sustainable development of renewable energy sources that are environmentally friendly. Biomass sources, particularly vegetable oils, have attracted much attention as an alternative energy source. They are renewable, non-toxic and can be produced locally from agriculture and plant resources.

Vegetable oils have long been promoted as possible alternatives for mineral Diesel. In fact, Rudolph Diesel, the inventor of the Diesel engine, used peanut oil as the fuel for its demonstration at the 1900 world exhibition in Paris and said, [1]. Vegetable oils are usually triglycerides, generally with a number of branched chains of different lengths and different degrees of saturation. Vegetable oils have lower calorific value than Diesel due to their oxygen molecules present. The cloud point and pour point are higher, and the cetane number is comparable to that of mineral Diesel [2,4,5]. The vegetable oils (30–200 cSt) have unfavorable pumping and spray characteristics as compared to mineral Diesel oil (4 cSt) at 40^0C due to viscosity. With vegetable oil as a fuel, short term engine performance results are comparable to those with mineral Diesel, but long term results with vegetable oil or blends with mineral Diesel lead to severe engine deposits, piston ring sticking, injector coking and thickening of the lube oil [5-10]. Vellguth [6] performed tests with heated vegetable oils and found that the deposits were even more than those of unheated vegetables oil. He tested vegetable oils on direct injection (DI) as well as indirect injection (IDI) engines and found that the problem in DI engines was more severe than that in IDI engines. High viscosity, low volatility and a tendency to polymerize within the cylinder are the root of many problems associated with direct use of vegetable oils as fuel [4,7]. The methods employed include preheating the oil, pyrolysis, microemulsion, blending and transesterification [2,3,6].

In comparison to mineral Diesel, biodiesel has a more favorable combustion and emission profile. Emissions of CO and particulate matter decrease by 45%, hydrocarbon (HC) emissions decrease by nearly 70% but NOx emissions increase by 10% with 100% biodiesel (B100) as a fuel [11]. The carbon cycle time for fixation of CO2 from biodiesel is quite small compared to mineral Diesel. It means that biodiesel usage reduces greenhouse gas emissions compared to mineral Diesel [12–15]. Biodiesel has a relatively high flash point, which makes it safer to handle. Agarwal et al. [16, 17] found that biodiesel provides good lubricating properties that can reduce component wear and enhance engine life.

EXPERIMENTAL SETUP

Experiments were conducted on a Kirloskar TV1 type, four stroke, single cylinder, water-cooled diesel engine test rig. Figure 1 shows the line diagram of the test rig used. Eddy current dynamometer was used for loading the engine. The fuel flow rate was measured on the volumetric basis using a burette and stopwatch. The engine was ran at constant speed of 1500 rev/min. The emission characteristics were measured by using five gas analyzer smoke meter and during the steady state operation. Experiments were conducted by using biodiesels selected for the study with four different combustion chamber shapes such as Hemispherical (HCC), toroidal Combustion chamber (TCC) and shallow depth combustion chamber (SDCC) shapes as shown in Figure 2.



1-Control Panel, 2-Computer system, 3-Diesel flow line, 4-Air flow line, 5-Calorimeter, 6-Exhaust gas analyzer, 7-Smoke meter, 8-Rota meter, 9,11-Inlet water temperature, 10-Calorimeter inlet water temperature,12- Calorimeter outlet water temperature, 13-Dynamometer, 14-CI Engine, 15-Speed measurement,16-Burette for fuel measurement, 17-Exhaust gas outlet, 18-Outlet water temperature, T1- Inlet water temperature, T2-Outlet water temperature, T3-Exhaust gas temperature.

Figure 1: Experimental set up.

Figure 2: Hemispherical, Toroidal and shallow depth shapes

The experiments are conducted at different loads at constant rated speed of 1500rpm. the ignition lag phase. In order to get proper air fuel mixing, a systematic air movement also called swirl is essential, which produce higher relative velocity between fuel droplets and air. Hemispherical combustion chamber is the baseline geometry considered. Table 2, shows the specifications of the engine.

Table 2: Specifications of the Engine

S. No.	Parameters	Specification
1	Type of engine	Kirloskar make Single cylinder four stroke direct injection diesel engine
2	No. of cylinders	01
3	No. of Strokes	04
4	Fuel	Diesel
5	Rated Power	5.2 KW/7 hp @ 1500 RPM
6	Bore & Stroke	87.5 & 110 mm
7	C R	17.5:1
8	Dynamometer arm length	185 mm

RESULTS AND DISCUSSIONS

Brake Thermal Efficiency (BTE)

The variations of brake thermal efficiency with brake power for different induced loads are shown in Fig 3. It is observed that BTE for diesel fuel mode of operation was higher than biodiesel RBMEO in both the piston operation over the entire load range. This is mainly due to lower calorific value of the biodiesels and lower volatility as well. The study with different combustion chamber shapes showed that for biodiesel operation with TCC resulted in better performance compared to hemispherical and shallow depth combustion chambers. Therefore substantial differences in the mixing process may not be present. It is observed that, maximum increase in efficiency is found at full load for all the pistons.

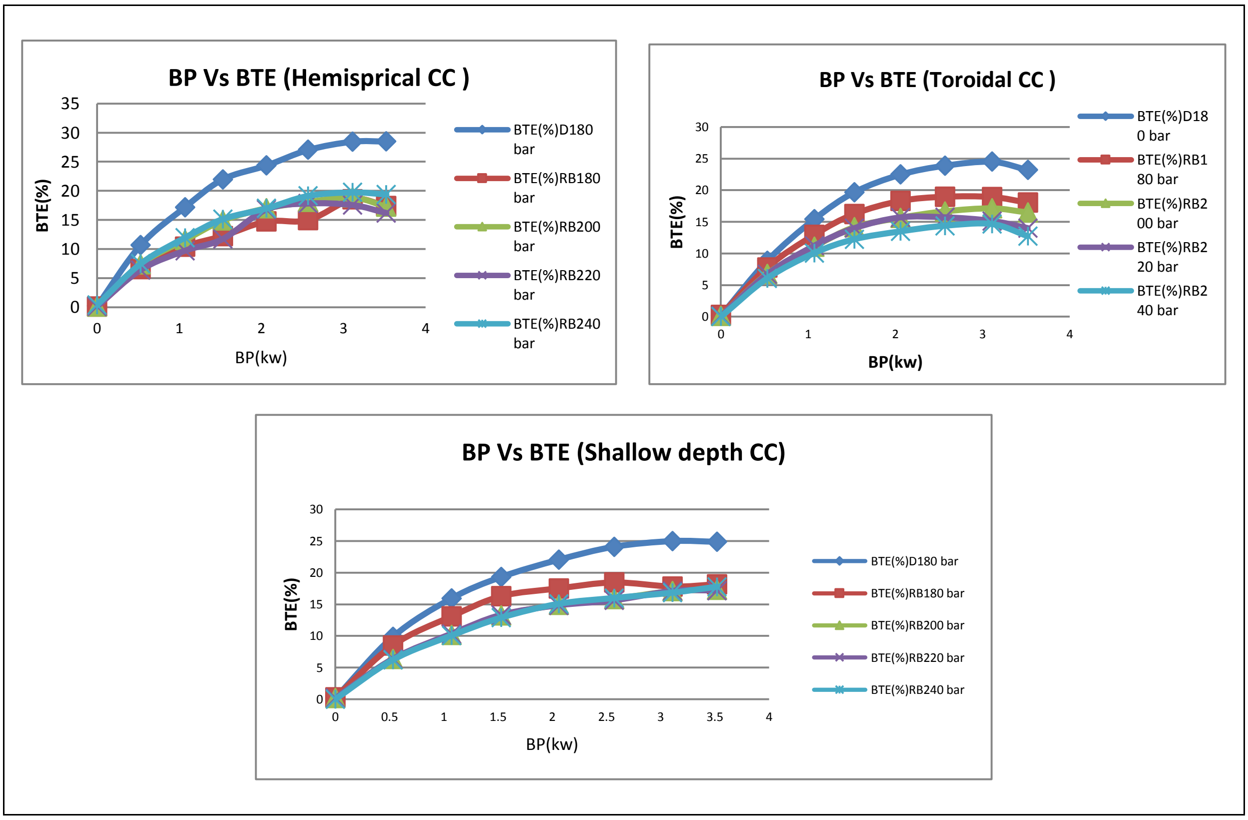


Figure 3: Variation BTE with BP

Brake Specific Fuel Consumption (BSFC)

The brake specific fuel consumption variations with brake power for different induced load rates are shown in Fig 4. It is observed that the maximum reduction in BSFC is found at full load conditions with different injecting pressures. Further observed the BSFC is further reduced by changing the piston bowl geometry for different flow rates of RBMEO at 180 bar injection pressure. This is because the inducement of enhanced air swirl in the combustion chamber leads to the complete combustion of charge in the combustion chamber with liberation of maximum energy.

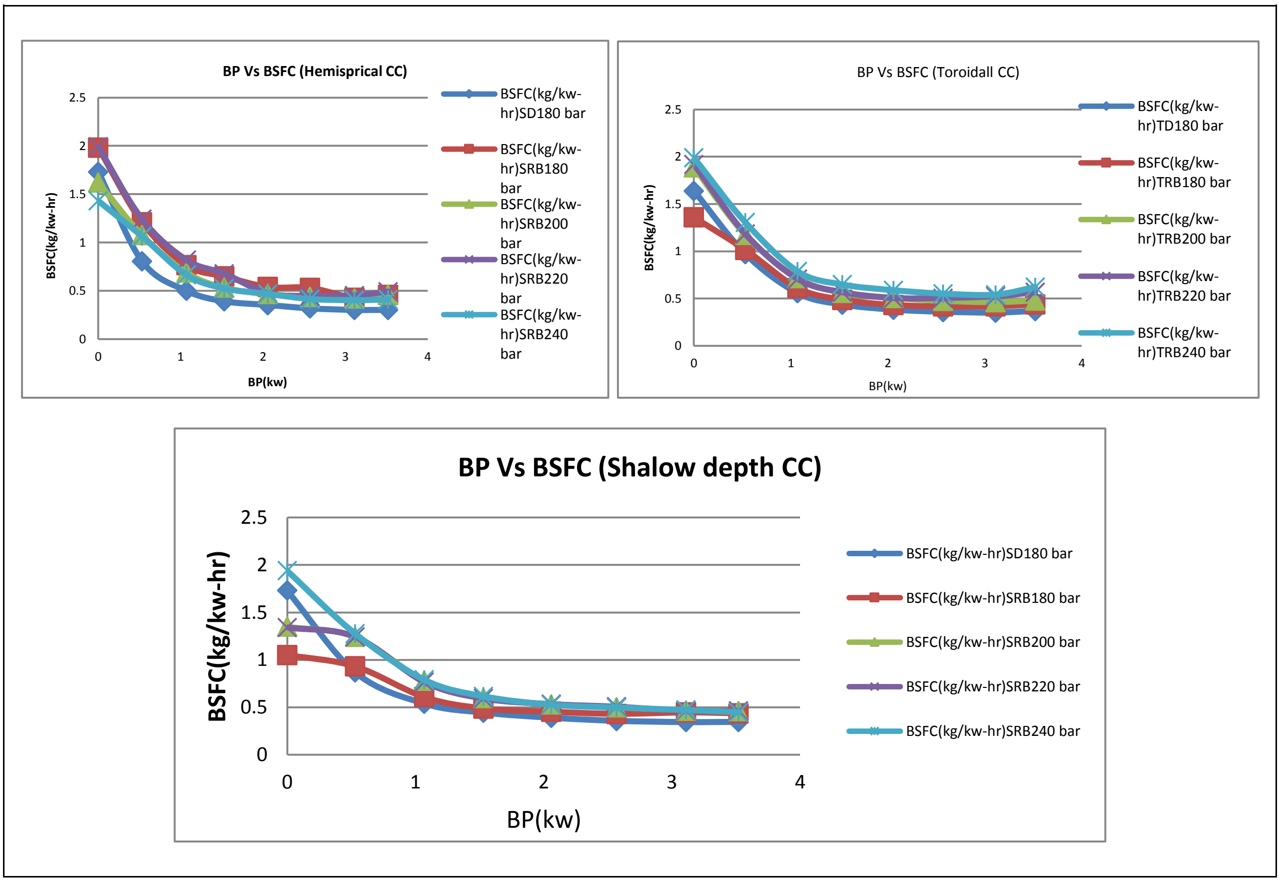


Figure 4: Variation BSFC with BP

CONCLUSION

In this experimental study, effect of different piston bowl geometry was investigated on direct injection single cylinder four stroke diesel engine at variable injection pressures were investigated. The following conclusions were drawn from results.

- Break Thermal Efficiency of diesel is increased at 180 bar injection pressure full load condition by 9.11% with HSCC, 5.59% with TCC and 6.72% with SDCC.
- Break Thermal Efficiency of RBMEO with HSCC is increased by 1.38% at 240bar injection pressure.
- Break Thermal Efficiency of RBMEO with TCC is increased by 4.28% at 180bar injection pressure.
- Break Thermal Efficiency of RBMEO with SDCC is increased by 0.44% at 180bar injection pressure.
- Break Specific fuel consumption of diesel is decreased at 180 bar injection pressure full load condition by 0.301Kg/Kwh with HSCC, 0.369 Kg/Kwh with TCC and 0.345 Kg/Kwh with SDCC.
- Break Specific fuel consumption of RBMEO is decreased at different injection pressure full load condition by 0.402Kg/Kwh at 240bar with HSCC, 0.48 Kg/Kwh at180bar with TCC and 0.436 Kg/Kwh at 180bar with SDCC.

From the above discussed properties of RBMEO biodiesel closer to the petroleum diesel and can be concluded that, it is well suited as an alternative fuel in the IC engines.

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