EXPERIMENTAL STUDIES ON THE CHARACTERISTICS OF DIESEL ENGINE WITH RICE BRAN OIL METHYL ESTER

Isabella Martínez[1]*, Diego Fernando Rojas[2], Elena Petrova[3], Marek Nowak[4], Sofia Andreou[5]
[1]Department of Applied Mathematics, Universidad Nacional de Colombia, Bogotá, Colombia
[2]Faculty of Engineering, Universidad de los Andes, Bogotá, Colombia
[3]Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia, Bulgaria
[4]Department of Theoretical Physics, University of Warsaw, Warsaw, Poland
[5]School of Engineering, University of Cyprus, Nicosia, Cyprus

ABSTRACT

The characteristics of a 4-S single cylinder water cooled constant speed naturally aspirated DI-CI engine with different blends of diesel-rice bran oil methyl ester combinations have been investigated. The investigation is focused on various performance characteristics like Brake specific fuel consumption, Brake thermal efficiency, Exhaust gas temperature, and combustion characteristics like heat release rate, pressure variation and emission characteristics like CO, NOX, HC. The fuel properties of rice bran oil methyl ester are found to be similar to those of diesel. A minor decrease in Brake thermal efficiency with significant improvement in reduction in exhaust gas temperature, CO, UHC is observed compared to diesel. The use of transesterfied rice bran oil methyl ester and its blends as fuel for diesel engine will reduce the dependence on fossil fuel and also decrease considerably the environmental pollution.

***Key Words**: Alternative fuels, diesel engine, blends, combustion, rice bran oil methyl ester, emission, performance.*

I. INTRODUCTION

The depletion of petroleum reserve and even increase in number of automobile in recent years makes it important to find alternative fuels. Of the various alternative fuels under consideration Bio diesel derived from rice bran oil methyl ester is one of the most promising alternative fuels to diesel because it can be produced from crops.

As raw rice bran oil is more viscous and low volatility, it affects injection pattern and atomization leading to incomplete combustion. The transesterfication is commonly used commercial processes to reduce the viscosity and increase volatility of rice bran oil. Transesterfication is a chemical process of converting very large, branched, triglyceride molecules of fat oil into smaller straight chain molecules similar in size of diesel. Many research works were carried out on the engine characteristics with edible oils like Soya bean[1], Palm[2], Cotton seed[3], Coconut[4], Corn[5] etc and non edible oils like Jatropha[6], Pongamia [7], Tobacco seed [8] and Tung [9]. Victor T. Wyatt, Melissa A. Hess et. al [10] studied emission levels of biodiesel produced from animal fats.

In this paper, the behaviour of rice bran oil methyl ester is reported. The explanation of observations has been based on inferences drawn from various characteristics. The most important disadvantage of petroleum diesel is its high sulphur content which participates in environment pollution. The blending of petroleum diesel with specified percentage of rice bran oil methyl ester Bio diesel decreases its disadvantage. This paper presents a complete analysis of rice bran oil methyl ester and its blends with diesel compared to standard petroleum diesel (PD). Blending rice bran oil methyl ester with petroleum diesel decreases viscosity and improves volatility. These improved properties results in better mixture formation and spray penetration.

II. EXPERIMENTAL SETUP AND PROCEDURE

Engine

Single cylinder 3.72 kW direct injection water cooled naturally aspirated stationary CI engine coupled with eddy current dynamometer is used for experimental study and detailed technical specifications are given in Table 1.

Table.1 Engine Specifications

Manufacture	Kirloskar Oil Engine
Engine	Single Cylinder Direct Injection Compression Ignition
Bore	80 mm
Stroke	110 mm
Compression ratio	16.5:1
Max power	3.72 kW
Rated speed	1500 rpm
Dynamometer	Eddy Current Dynamometer
Type of Pressure sensor	Piezo electric type
Pressure sensor resolution	0.1 bar for cylinder pressure,1.0 bar for injection pressure
Crank angle sensor resolution	1 degree

Fig. 1 shows the photograph of the experimental setup. The entire experimental setup consists of engine, eddy current dynamometer, display panel, computer and exhaust gas analyser. Exhaust gas analyser is used to investigate the emission characteristics. The technical specifications of exhaust gas analyser are given inTable 2.

Fig.1 Photograph of Engine Test Rig

Table.2 Exhaust gas analyser specifications

Exhaust Gas Analyser make and model: INDUS make and PEA 205		
	Range	Resolution
NO	0-5000 ppm	1 ppm
HC	0-15000 ppm	1 ppm
CO	0-15.0%	0.01%

The engine is tested with rice bran oil methyl ester (B100), B20 (20%B100 +80%PD), B30 (30%B100+70%PD) and B40 (40%B100+60%PD) and obtained results are compared with standard petroleum diesel (PD/B0). The engine is allowed to maintain at constant speed of 1500 rpm and steady state. An eddy current dynamometer is used to measure load (BP). Tests are conducted on engine at 25% (6 kg/093 kW), 50% (12 kg/1.86kW), 75% (18 kg/2.73 kW) and 100 %(24 kg/3.72kW) loads. To record cylinder pressure, heat release rate, mass fraction burnt and all other required parameters, "Lab View" software developed by Tech-Ed, Bangalore, India, is used.

Fuel

Rice bran oil methyl ester fuel produced from transesterfication is used in this study. The useful properties of rice bran oil methyl ester and ASTM standard specifications for bio diesel are given below in Table 3. From these properties, it is observed that the Rice bran oil methyl ester fuel properties are similar to petroleum diesel and this indicates that the rice bran oil methyl ester fuel can be used in existing diesel engine without any modification and used as alternative fuel by blending with diesel and pure form. Rice bran oil methyl ester is a Biodiesel and its fatty acid composition is shown in table 4.

Table.3 Properties of fuels

Property	**ASTM D-6751**	**IS 15607 : 2005**	**Rice bran oil**
Density	890 kg/m^3	IS 15607 : 2005	867 kg/m^3
Flash point (closed cup)	130°C min. (150°C average)	96.5 %	158
Kinematic viscosity at 40°C	1.9-6.0 mm^2/s	2.5-6.0 mm^2/s	3.21
Cetane Number	47 min.	47 min.	50
Acid number, mg KOH/g	0.80 max.	0.75	.45
Calorific value	36000 kj/kg	36500 kj/kg	38623 kj/kg

Table.4 Fatty acid composition of Rice bran oil methyl ester

Fatty acid	**Wt (%)**
Myristic(14:0)	0.20
Palmitic(16:0)	18.30
Palmitoleic(16:1)	4.20
Stearic(18:0)	6.05
Oleic(18:1)	53.66
Linoleic(18:2)	16.72
Linolenic(18:3)	0.42
Eicosenoic(20:1)	0.44

III. RESULTS AND ANALYSIS

This paper compares variation of Brake Specific Fuel Consumption (BSFC), Brake Thermal Efficiency (BTE), Brake Specific Energy Consumption (BSEC), Exhaust Gas Temperature (EGT), Cylinder pressure, Heat release

rate, Mass fraction burnt, Cylinder peak pressure and exhaust emission Hydro carbons (HC), Carbon monoxide (CO), and Oxides of nitrogen (NOx) of Rice bran oil methyl ester and its blends with those of petroleum diesel.

Performance Characteristics

The performance characteristics of the engine are the very important criterion for selection and suitability of alternate fuels. This study evaluates BSFC, BTE, BSEC, EGT of Rice bran oil methyl ester and diesel blends

a. Brake Specific Fuel Consumption (BSFC)

Calorific value of Rice bran oil methyl ester(B100) is lower than diesel. Hence the BSFC is slightly higher than that of the diesel for Rice bran oil methyl ester and its blends. Fig.2 shows the variation of BSFC of Rice bran oil methyl ester and its blends with engine load. BSFC decrease with increase in engine load. At full load BSFC of Rice bran oil methyl ester (B100) is 15.16% higher than PD(B0). BSFC of B20 fuel is very closer to PD at full load.

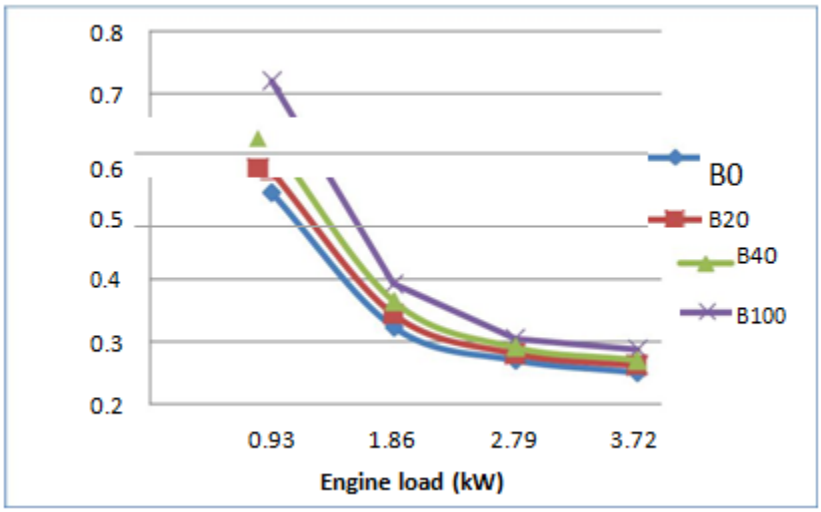

Fig.2 Variation of BSFC with engine load (BP)

b. Brake Thermal Efficiency (BTE)

Fig.3 shows the variation of BTE of pure Rice bran oil methyl ester (B100)and various Rice bran oil methyl ester & diesel blends compared to pure diesel. BTE increases with engine load for all fuels.The increase of percentage of Rice bran oil methyl ester in diesel blend decreases the BTE at all loads. It is observed that B20 fuel blend has BTE very closer to PD at 3.72 kW load.

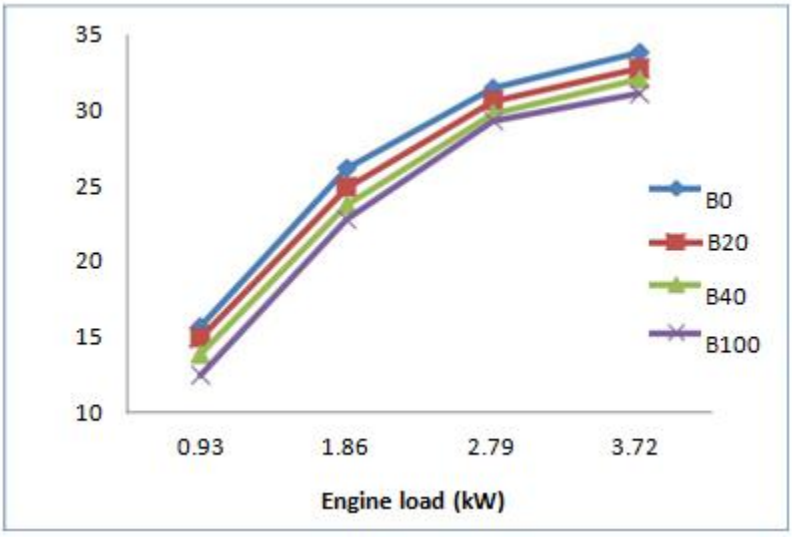

Fig.3 Variation of BTE with engine load (BP)

c. Brake Specific Energy Consumption (BSEC)

The significance of brake specific energy consumption is to know the fuel energy required to produce unit brake power. Fig.4 shows the variation of BSEC with engine load for different Rice bran oil methyl ester and diesel blends compared to pure diesel. BSEC decreases with engine load and is low at full load for all fuel blends. BSEC of PD is lower than Rice bran oil methyl ester at all loads, this may be due to higher calorific value of diesel than Rice bran oil methyl ester.

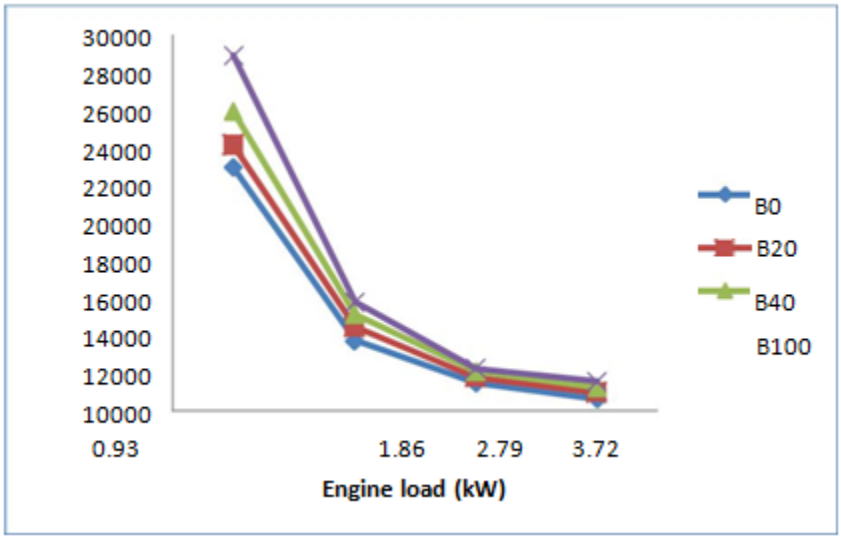

Fig.4 Variation of BSEC with engine load (BP)

d. Exhaust Gas Temperature (EGT)

Fig.5 shows the exhaust gas temperature variation for the test fuel with engine load. It is observed that the exhaust gas temperature increases with load because to meet the higher power requirement more fuel has to be burnt. EGT of Rice bran oil methyl ester is very much lower than PD at all loads. The EGT of Rice bran oil methyl ester is 360°c at full load which is 6.25% less than PD. This may be due to lower calorific value of Rice bran oil methyl ester.

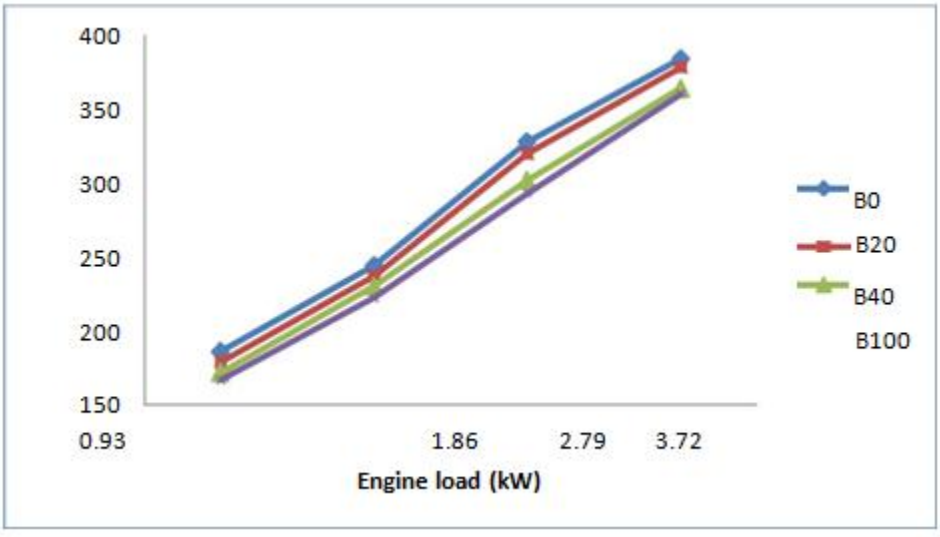

Fig.5 Variation of EGT with engine load (BP)

Combustion Characteristics

This section highlights the effect of Rice bran oil methyl ester and its blend in diesel on combustion characteristics like cylinder pressure variation, heat release rate and also mass fraction burnt with crank angle and compared with PD. This section also includes the variation of cylinder peak pressure of various fuels with engine load.

a. Cylinder Pressure

Fig.6 shows variation of cylinder pressure with crank angle for complete cycle at 2.79 kW load. It is observed that the curves are overlapped for all fuel blends during cycle except the crank angle range between $360^{O}$to 390^{O} (i.e. near to TDC). For the crank angle range between 350^{O} to 450^{O}, the cylinder pressure variation is shown in fig.7 to know the attainment of peak pressure for all fuels. From this, it is observed that the attainment of peak pressure is slightly delayed with increase in percentage of Rice bran oil methyl ester in diesel.

b. Heat Release Rate

Knowledge of heat release rate of fuel is very essential for cooling system design. The comparison of heat release rate of various fuel combinations at 2.79kWload is shown in fig.8. The maximum heat release rate(56.49 $J/^{0}ca$) is observed for Rice bran oil methyl ester fuel at 394^{0} crank angle. Cumulative heat release rate for crank angle ranges between $350^{O}$to $450^{O}$is shown in fig.9.The area under cumulative heat release rate curve indicates the net heat released during the given period of cycle. It is observed that the area under B0(PD) is higher than all other fuel blends. This is due to liberation of more heat of PD than Rice bran oil methyl ester during combustion.

c. Peak Pressure

Fig.10 shows the variation of cylinder peak pressure of various fuel blends with engine load. Peak pressure increases with increase in engine load for all fuels. Peak pressure of Rice bran oil methyl ester is higher than PD at 2.79kW load, but at 3.72k w load Rice bran oil methyl ester peak pressure is lowered.

d. Mass Fraction Burnt

Fig.11 indicates the variation of mass of fuel burnt with crank angle at 2.79 kw engine load. This graph describes burning rates of various fuel blends. For B0(PD) fuel burning rate is very high in the beginning of combustion compared to Rice bran oil methyl ester and other blends. Though the burning is initiated at 10^{o} bTDC, but rapid increase in burning rate is observed immediately after TDC only.

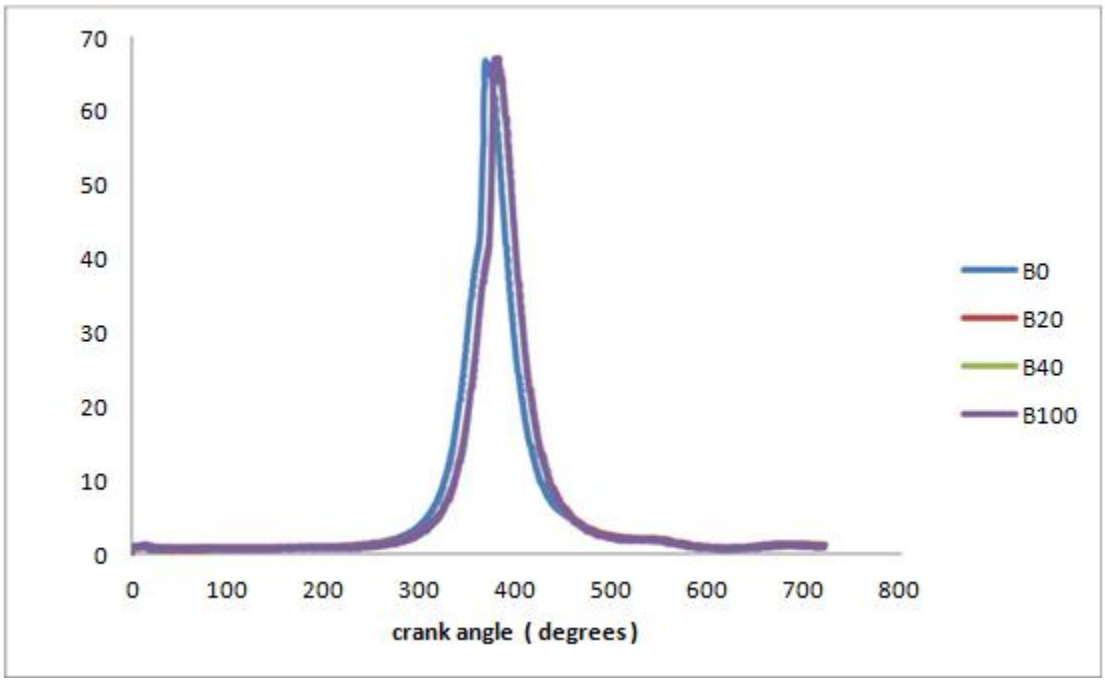

Fig.6 Variation of cylinder pressure with crank angle at 2.79 kW load

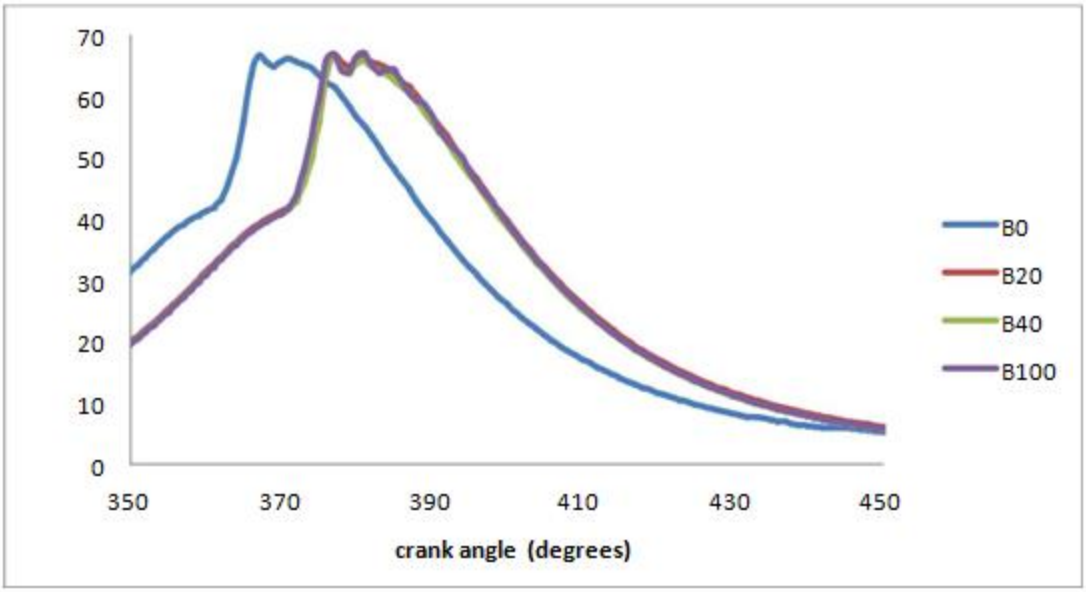

Fig.7 Variation of cylinder pressure with crank angle near TDC at 2.79 kW load

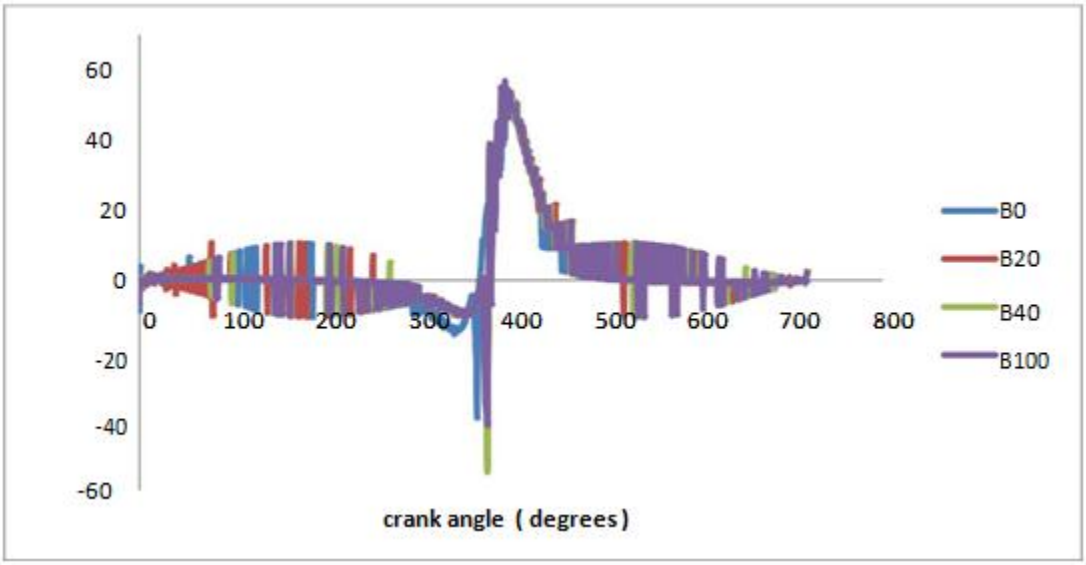

Fig.8 Variation of Heat release rate with crank angle at 2.79 kW load

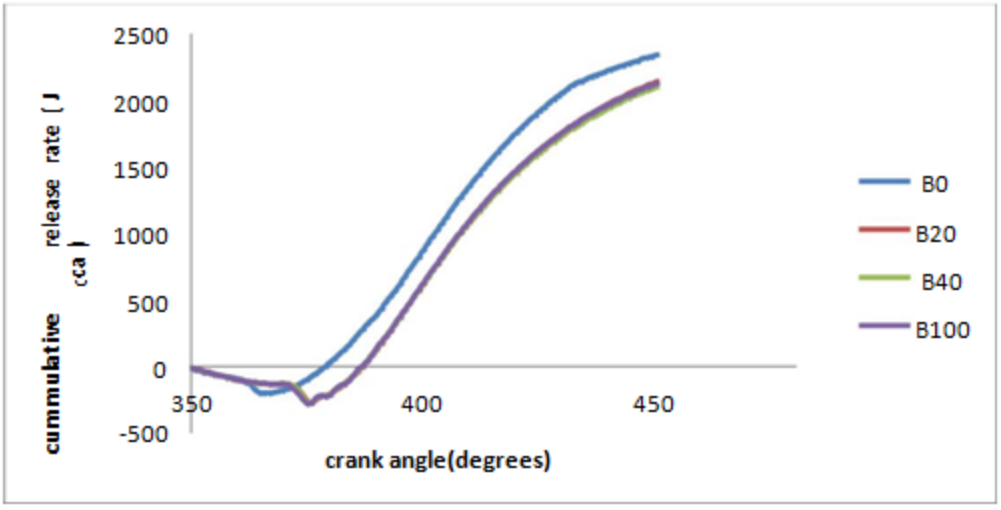

Fig.9 Variation of Cumulative Heat release rate with crank angle at 2.79 kW load

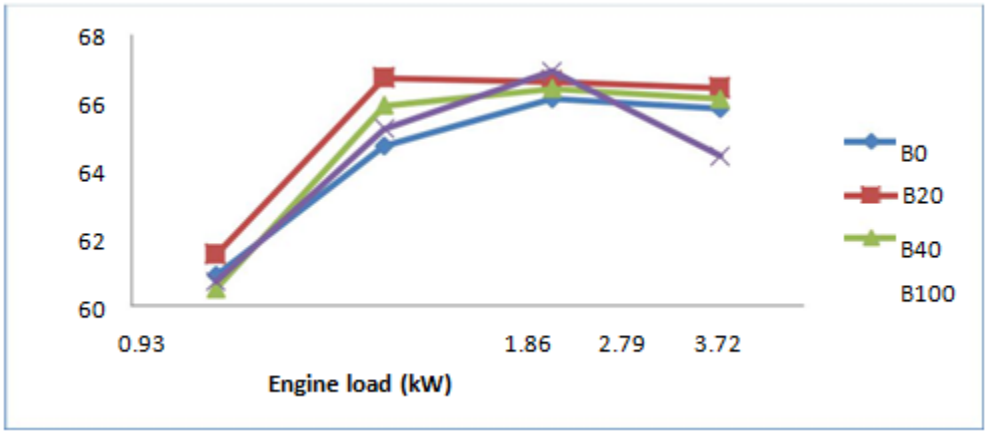

Fig.10 Variation of cylinder peak pressure with engine load (BP)

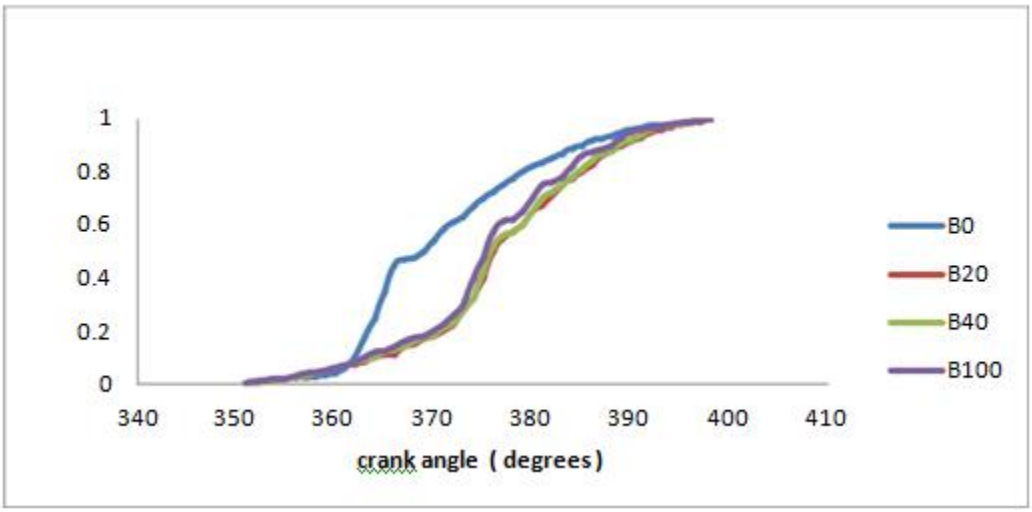

Fig.11 Variation of Mass fraction of fuel burnt with crank angle at 2.79 kW load

Emission Characteristics

Engine emission characterstics are analysed based on variation of HC (ppm), NOX(ppm), CO(%) with respect to engine load. Fig.12 shows variation of HC with engine load. HC emissions increase with increase in engine load for all fuel blends. Rice bran oil methyl ester (B100) HC emissions are very much lower than PD (B0) at all load conditions. This may be due to promotion of oxygenated fuel (Rice bran oil methyl ester) lead to complete combustion. Fig.13 shows NOX emission variation with respect to engine load. NOX increases with increase in engine load for all fuels. Rice bran oil methyl ester NOX emissions are much greater than PD at all load conditions. The oxygenated Rice bran oil methyl ester fuel combustion leads to increse in NOX emissions. The variation of CO emissions with engine load for all fuel blends is shown in the Fig.14. CO emission increses with increase in engine load but at particular load CO emissions decrease with increase of peercentage of Rice bran oil methyl ester in the blend. Comparatively the complete combustion of the oxygenated Rice bran oil methyl ester fuel decreases the CO emissions.

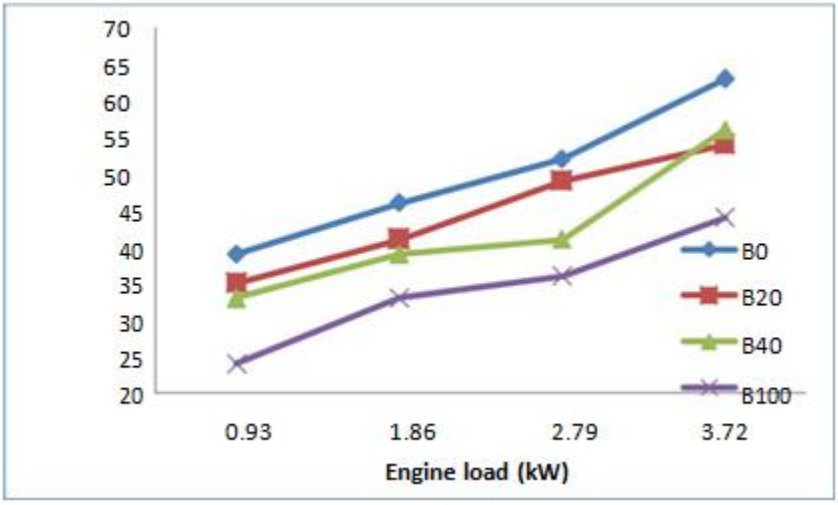

Fig.12 Variation of HC with engine load (BP)

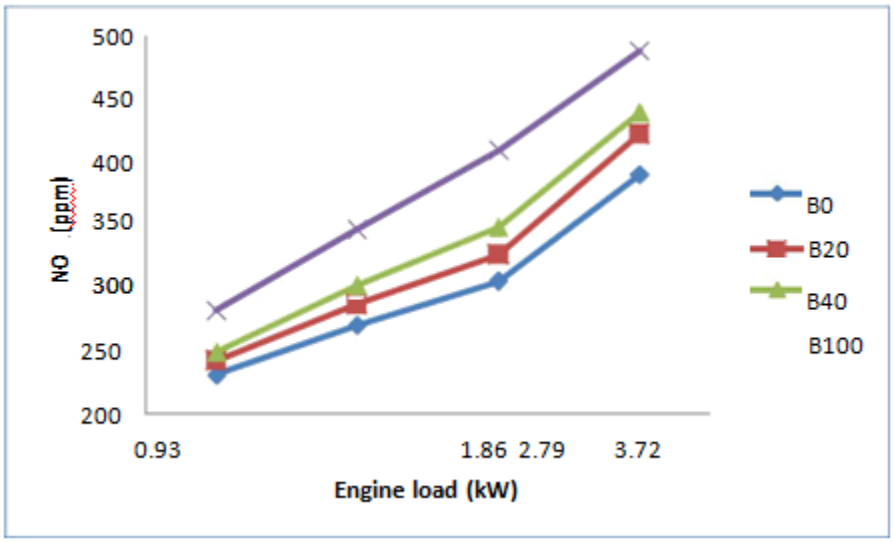

Fig.13 Variation of NOX with engine load (BP)

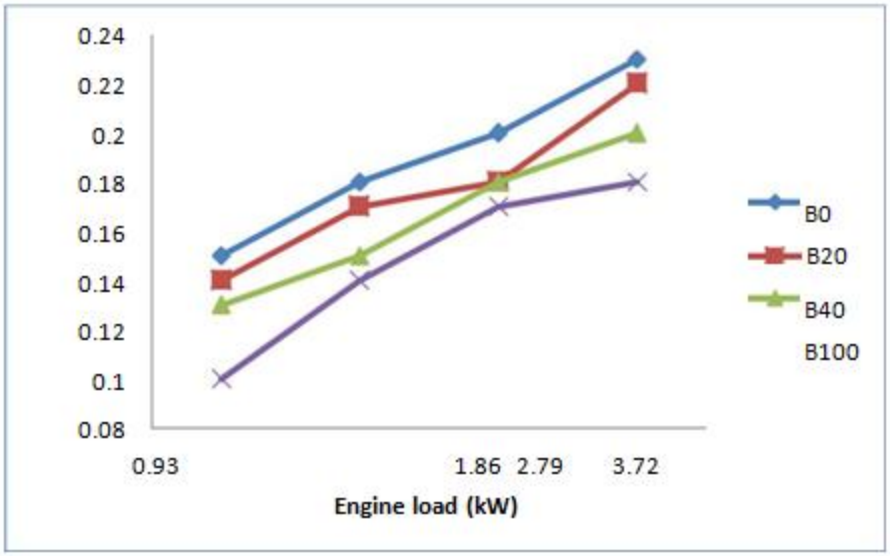

Fig.14 Variation of CO with engine load (BP)

IV. CONCLUSIONS

The performance, combustion and emission characteristics of 3.72kW DI-CI engine fueled with Rice bran oil methyl ester and its blend have been analysed and compared with base line petroleum diesel. The present study results are summarised as follows.

- The BSFC and BSEC decreases with increase in engine load, and also increases with % Rice bran oil methyl ester in the blend due to its lower calorific value.
- EGT increase with increase of engine load and decreases with % Rice bran oil methyl ester in the blend.
- BTE decreases with increase in % of Rice bran oil methyl ester in the blend and increases with engine load.
- Pressure rise and heat release rates of Rice bran oil methyl ester fuel are very closer to PD at all loads, attainment of peak pressure is delayed due to lower burning rate of Rice bran oil methyl ester compared to diesel.
- Higher oxygen content in the Rice bran oil methyl ester compared to PD results in better combustion and leads to decrease in CO, HC and increases in NOX.
- The Rice bran oil methyl ester satisfies all the important properties of Rice bran oil methyl ester fuel as per ASTM standard specifications of Biodiesel and achieved significant engine characteristics

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