IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# Performance Evaluation Of A Compression Ignition Engine Using Ethanol With Biodiesel

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**Abstract:** Infact the idea of using ethanol has really been around since the 18$^{th}$ century, it has recently become increasingly popular as a result of the diminishing supply of fossil fuels, high fuel prices, air pollution, global warming. For IC engines, ethanol is a possible alternative fuel. Due to its renewable nature, seeming ability to replace gasoline, ethanol is one of the most significant substitute fuels for petroleum gasoline. In IC engines, ethanol can be blended with fossil fuels without requiring any modifications. So, based on the significance of using ethanol blend with biodiesel in an IC engine, a performance evaluation of using ethanol blend with biodiesel tests were carried out in accordance with the BIS. The tests were conducted using ethanol blends at various ratios, such as E0, E5, E8, E10, and E12. The load was varied from no load to full load for normal biodiesels. A maximum BP of 4.567 kW was observed from W.V.O. (B100), BSFC of P.P. [B95E5] higher than other fuels ratios i.e., 0.578 kg/kW/hr, BTE of [B92E8] was 24.87% as compared with other fuels blends.

*Key words:* Ethanol blend, Performance, Brake Specific Fuel Consumption, Brake Thermal

Efficiency.

## Introduction

Most internal combustion (IC) engines run on petroleum fuels, which are limited and will run out in around 40 years. limited energy Some publications claim that there may be an energy shortage in the future. Around 35% of all petroleum fuels are used as fuel by IC engines, and the exhaust fumes these engines produce is one of the main sources of environmental pollution. Ethanol has been suggested as an alternate fuel for diesel engines. The main advantages of an internal combustion engines over external combustion engines are greater mechanical simplicity, higher overall efficiency, reduced cost and lower ratio of weight to bulk output due to the absence of auxiliary apparatus like boiler, condenser and lesser requirement of water for dissipation of energy through the cooling system. The revolution in the lifestyle system of the people caused by an internal combustion engine in transport vehicles made an extensive use of which it became possible due to tremendous development in an internal combustion engine by using fossil fuels that made unique event of the twentieth century (Mathur and Sharma, 2015). During twentieth century the global crises triggered awareness amongst many countries of their vulnerability to oil embargoes and shortages (Hansen *et al.*, 2005). It is anticipated that on an average, demand for fossil fuels will go up from an expected 134000 million litres in the year of 2015 to 225000 million litres in the year of 2026. The consumption of fossil fuels at this rate would cause irreversible energy crisis along with a sharp increase in carbon footprints and other emissions which would not only cause environmental hazards but also deteriorate human health (National policy on Biofuel).

Biofuels are considered to provide energy security which is eco-friendly, recyclable and biodegradable but Biodiesel and alcohols are considered to be the potential renewable energy also. Many research on biodiesel has been conducted by the researcher and found that diesel fuel can be replace to a greater extent by bio-diesel but diesel engine running on biodiesel produces higher $NO_x$ emission as compared to diesel fuel. There exist about more than 350 vegetable oil bearing crops have been studied by different researcher, among them most widely used vegetable oils such as jatropha curcas, tamanu oil, mustard oil, rapeseed oil, palm oil, soyabean oil, sunflower oil etc are consider to be the future potential fuel for diesel engines (Demirbas, 2008). To know the performance and emission characteristics of diesel engines using biodiesels like tamanu oil biodiesel was used and analysed with the diesel in different ratios such as B15, B25, B50 and B100 respectively the results shows that higher BTE of 30% for B15 as compared to diesel and lowest BSFC was observed under all loads. Also, with 100% biodiesel mechanical efficiency was higher at all loads and B100 was produce higher smoke at all loads along with higher NOx emission from the engine (Deepan, 2015). The Comparative study of using diesel and biodiesel in a single cylinder diesel engine was conducted as per the Bureau of Indian standard for four biodiesels such as Indizel, DSB, WVO and *Pongamia pinnata* in different blended ratios like B25, B50, B75 and B100. Among all biodiesels dairy scum biodiesel has received more attention. A maximum BP of 4.504 kw was observed, BTE of DSB was 30.05% as compared to other biodiesels. The least and highest unaccounted heat loss among four biodiesels were DSB B75 [346.49 kJ/kg] and DSB B50 [763.8 kJ/kg]. However, DSB, Indizel [B75] and DSB [B75] have shown good value in term of heat loss respectively as compare to standard diesels in term of their performance parameters are concern (Donadkar, 2022).

**Materials and methods**

**2.1 Experimental setup**

The experiments were conducted as per the Indian standard methods of test for Internal Combustion Engines Part IV Declaration of power, Efficiency, Fuel consumption and Lubricating oil consumption. The net output in brake power of the engine which is capable of delivering continuously, at the rated crankshaft speed [rev/min] under the operating conditions of manufacturers test bed was adjusted to standard reference condition specified in section I of IS:10000 [Part II]-1980. The engine shall be capable of delivering an output of 10 percentage in excess of its rated output at its rated speed for a period of 1 hour in any period of 12 hours continuous running without undue heating of the engine or any other mechanical trouble. So accordingly, the experiments were conducted at sea level in marine engine laboratory of Technology Wing College of Fisheries, Mangaluru.

**2.2 Diesel engine test rig**

The internal combustion engine used for this experimental work was single cylinder vertical 4-stroke naturally aspirated water-cooled diesel engine having 5 BHP rated power running at 1400 rpm. The Diesel engine test rig setup and specifications of the Single Cylinder Vertical Diesel Engine is as shown in the plate 1 and Table 1. The engine consists of four main parts such as Single Cylinder 4 Stroke Diesel Assembly, Rope Brake Dynamometer Assembly, Fuel Consumption Measuring Unit and Exhaust Gas Calorimeter. The main engine is coupled to a brake drum dynamometer to measure to torque and brake power. Fuel Consumption Measuring Unit connection was done properly and the air was completely removed before cranking the engine.

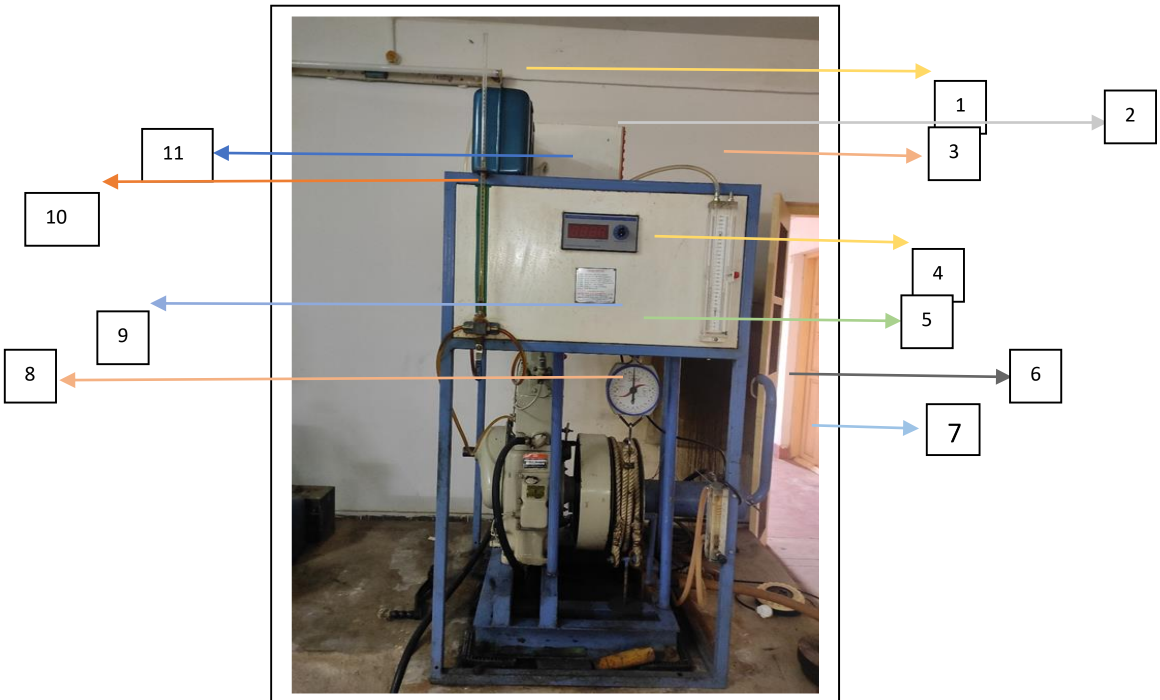


**Plate 1: Diesel engine test rig**

1- Fuel tank, 2- Orifice meter, 3- Air consumption measuring unit, 4- Spring balance, 5- Rope brake dynamometer, 6- Extension board, 7- Loads, 8- Weight hanger, 9- Hanging rope, 10- BSFC measuring unit, 11-Temperature indicator

**Diesel Engine Test rig Specifications**

| Specification | Remarks |
|---|---|
| Make | Rocket Engineering, Kolhapur, Maharashtra |
| Description | Four Stroke, Single Cylinder Diesel Engine |
| Fuel used | Diesel, Biodiesel and Ethanol |
| Bore | 80 mm |
| Stroke | 110 mm |
| Speed | 1400 RPM |
| Rated load | 16 Kg |
| Compression ratio | 16.7:1 |
| Output rated power | 5 HP |
| Cooling system | Water cooling system |
| Method of starting | Cold starting with the help of starting handle |

### 2.3 Preparation of W.V.O. and ethanol

Different amounts of the ethanol were mixed with regular W.V.O. The blend samples for both fuels were made by mixing 100% (1500 ml) pure W.V.O., W.V.O. denoted as B100, 95% (1420 ml) W.V.O. with 8% (120 ml) ethanol, B92E8, and 88% (1320 ml) W.V.O. with 12% (180 ml) ethanol, B90E10. The ratios of ethanol and diesel are displayed in Table 2 and Plate 2.

| Sr. No. | Ratio's of W.V.O. and ethanol | Type of fuel |
|---|---|---|
| 1 | 100% Pure W.V.O. | B100 |
| 2 | 95% W.V.O. + 5% Ethanol | B95E5 |
| 3 | 92% W.V.O. + 8% Ethanol | B92E8 |
| 4 | 90% W.V.O.+ 10% Ethanol | B90E10 |
| 5 | 88% W.V.O. + 12% Ethanol | B88E12 |

**Table 2: Ratio's of W.V.O. and Ethanol**

**Plate 2: Defferent Ratios of W.V.O. & Ethanol**

## Result and discussion

In order to assess performance metrics including brake horsepower, brake specific fuel consumption, and brake thermal efficiency, comparison research was done to determine the impacts of blending ethanol with biodiesel fuel. For this experiment, a single-cylinder, vertical, four-stroke, naturally aspirated, water-cooled diesel engine with a 5 BHP rated power output was employed. It rotated at 1400 RPM. The tests were carried out by altering the load for ethanol blends with conventional biodiesel such as waste vegetable oil in different blended ratios such E0, E5, E8, E10, and E12 from no load to full load.

### 3.1 Brake Horse Power

Stalin and Prabhu, (2007) reported the influence of load on brake power for diesel and PP biodiesel in different ratios. It is observed that BP was higher for dual fuel combinations from B5 to B30 than diesel. In the case of B40 the brake power was more or less equal to the pure diesel. When examining the effects of load on brake horsepower for various fuels, it was found that W.V.O. B100 had the highest braking power 4.567 kW for the highest load. Then, the respective power outputs for the W.V.O. and the ethanol blends B95E5, B92E8, B90E10, and B88E12 were 4.588 kW, 4.428 kW, 4.480 kW, and 4.494 kW. At full load, B92E8 and B95E5 showed the lowest and highest BP, respectively.

- Brake Horse Power was calculated by using the following formula.

$$BP = \frac{2\pi NT}{60,000}$$

Where, T is torque in (Nm) and N is the rotational speed in revolutions per minute (RPM).

**Table 3: B H P from ¼ load to full load with neat W.V.O. and blends Ethanol**

| Load | Brake Horse Power (kW) | | | | |
|---|---|---|---|---|---|
| | B100 | B95E5 | B92E8 | B90E10 | B88E12 |
| No load | 0.212 | 0.212 | 0.212 | 0.212 | 0.212 |
| ¼ load | 1.288 | 1.288 | 1.284 | 1.282 | 1.288 |
| ½ load | 2.343 | 2.340 | 2.302 | 2.313 | 2.333 |
| ¾ load | 3.441 | 3.419 | 3.365 | 3.381 | 3.398 |
| Full load | 4.567 | 4.558 | 4.428 | 4.480 | 4.494 |

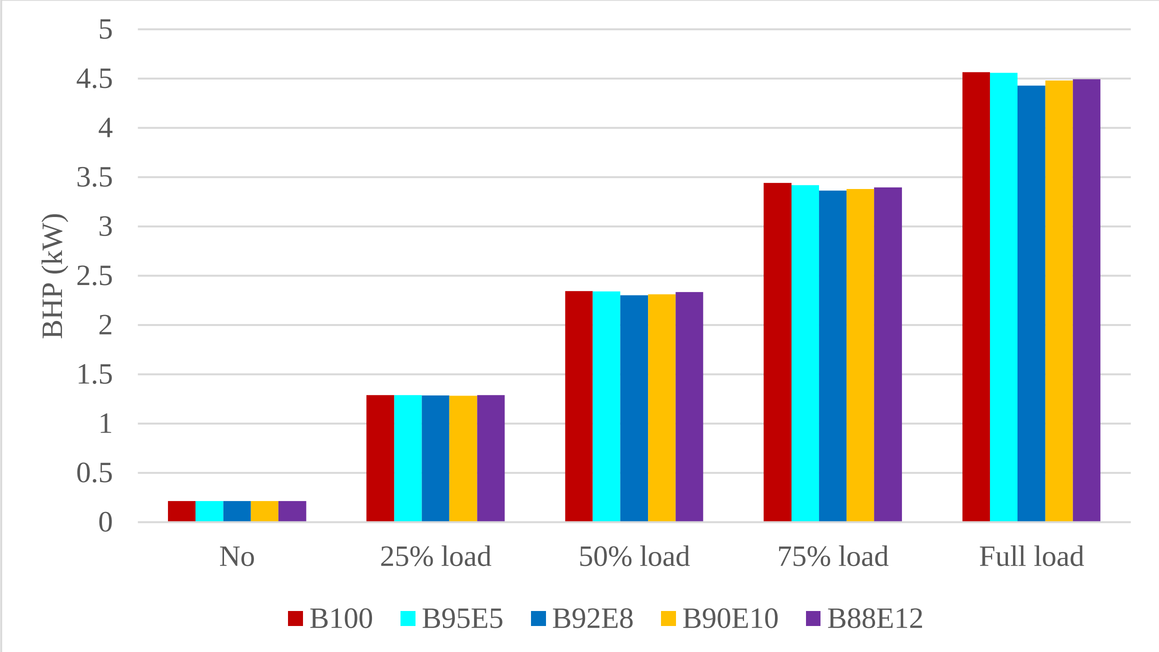


**Fig 1: BHP from different loads for W.V.O. and various blends of Ethanol**

### 3.2 Brake Specific Fuel Consumption

While the investigation here as the load grew during the trial, the amount of fuel used specifically for the brakes dropped. The lowest observed BSFC for B100 was 0.405 kg/kW/hr for maximum load neat W.V.O., and the highest observed BSFC for W.V.O. blend with ethanol B92E8 was 0.578 kg/kW/hr. Other blends with observed BSFC included B95E5, B90E10, and B88E12, with values of 0.406, 0.479, and 0.438 kg/kW/hr, respectively. Najafi *et al.*, (2009) found the connection between brake specific fuel consumption and engine speed for various gasoline blends E20 was 0.320

kg/kW/hr. As the ethanol percentage rises, the BSFC was decreased. The BSFC reduces to its minimal values as engine speed rises to 3500 rpm.

- Brake Specific Fuel Consumption was calculated by using the following formula.
  *BSFC*= (Q fuel/BP), Where, BSFC = Brake Specific Fuel Consumption, ***(kg/kW/hr)***
  Q fuel = Weight of fuel consumption, ***(kg/hr)*** BP = Brake Power, ***(kW)***

**Table 4: Brake Specific Fuel Consumption from ¼ load to full load with neat W.V.O. and blends of Ethanol**

| Load | Brake Specific Fuel Consumption (kg/Kw/hr) | | | | |
|---|---|---|---|---|---|
| | B100 | B95E5 | B92E8 | B90E10 | B88E12 |
| No load | 5.849 | 6.226 | 6.089 | 5.844 | 6.207 |
| ¼ load | 1.253 | 1.264 | 1.292 | 1.297 | 1.307 |
| ½ load | 0.809 | 0.815 | 0.902 | 0.898 | 0.888 |
| ¾ load | 0.573 | 0.548 | 0.715 | 0.668 | 0.613 |
| Full load | 0.405 | 0.406 | 0.537 | 0.479 | 0.438 |

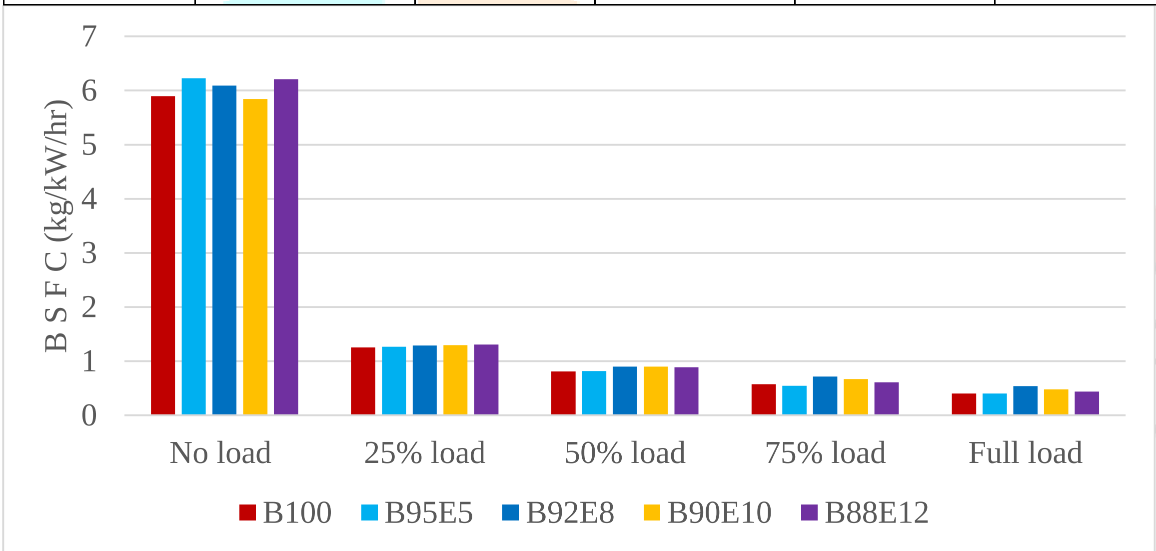


**Fig 2: Brake Specific Fuel Consumption from different loads for W.V.O. and various blends of Ethanol**

### 3.3 Brake Thermal Efficiency

Madiwale *et al.*, (2018) reported brake thermal efficiency is higher for diesel-biodiesel-ethanol blends than for biodiesel-diesel blends. This is due to more oxygen content which promotes maximal blend combustion in the combustion chamber. The findings of the current testing show that the B95E5 brake's highest Brake Thermal Efficiency was 24.87% under conditions of maximum load. The W.V.O. mix with ethanol B92E8 had the lowest BTE, which was 18.71%. Additionally, the BTE recorded for other blends like B100, B90E10, and B88E12 was 24.65, 21.18, and 23.28%, respectively. According to Agarwal et al. (2015), the unresolved rivalry between viscosity, calorific value, and oxygen content led to poorer efficiency in blends with greater ratios of biodiesels like B40, B60, B80, and B100. Due to the biodiesel's higher oxygen content and lower calorific value, the BTE was reduced, and at the same time, viscocity enhanced lubricating properties due to atomization properties.

- The Brake Thermal Efficiency was calculated by the brake power of the engine was calculated by using the following formula.

$$BTE = \frac{BP \times 60}{H} \times 100$$

Where, BTE - Break thermal efficiency, *%*

H - Heat Supplied by the fuel, ***(kJ/kg)***

BP - Brake Power, ***(kW)***

**Table 5: Brake Thermal Efficiency from ¼ load to full load with neat W.V.O. and blends of Ethanol**

| Load | Brake Thermal Efficiency (%) | | | | |
|---|---|---|---|---|---|
| | B100 | B95E5 | B92E8 | B90E10 | B88E12 |
| No load | 1.71 | 1.57 | 1.66 | 1.67 | 1.67 |
| ¼ load | 8.02 | 7.81 | 7.83 | 7.86 | 7.64 |
| ½ load | 12.39 | 12.35 | 11.15 | 11.26 | 11.39 |
| ¾ load | 17.41 | 18.05 | 13.86 | 15.12 | 16.61 |
| Full load | 27.65 | 24.87 | 18.71 | 21.18 | 23.35 |

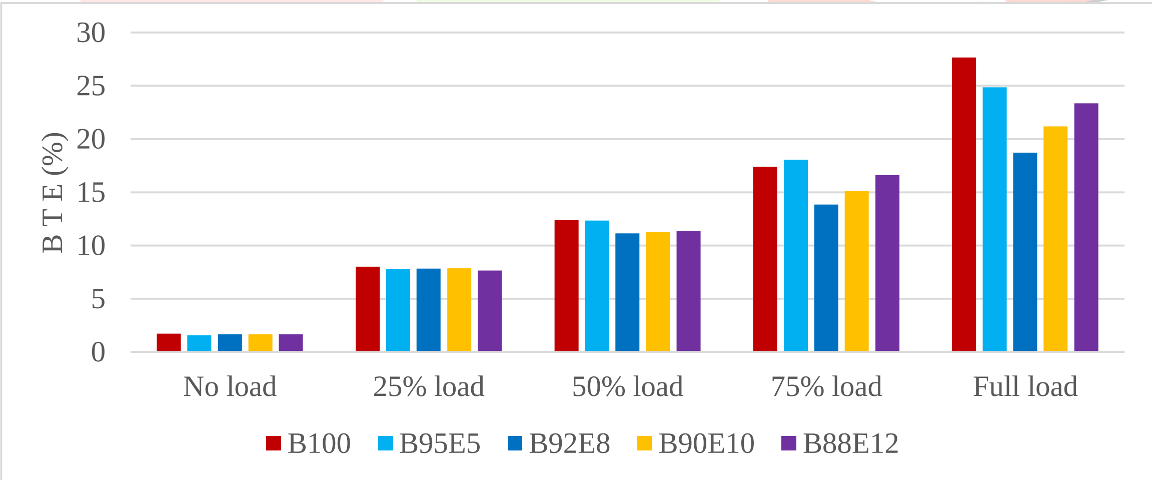


**Fig 3: Brake Thermal Efficiency from different loads for W.V.O. and various blends of Ethanol**

## Conclusion

- It is observed that BP was higher for dual fuel combinations from W.V.O. and Ethanol. In the case of B100 the brake power was more or less equal to the pure diesel.
- Brake specific fuel consumption observed during experiment going on that time BSFC increase when ethanol percent increase. Lowest BSFC in B100 was 0.405 kg/kW/hr.
- The findings of the current testing show that the B95E5 brake's highest Brake Thermal Efficiency was 24.87% under conditions of maximum load. The W.V.O. mix with ethanol B92E8 had the lowest BTE,

which was 18.71%. Additionally, the BTE recorded for other blends like B100, B90E10, and B88E12 was 24.65, 21.18, and 23.28%, respectively.

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