# Experimental Studies of a Diesel Engine Run with Different Fuel Blends

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**ABSTRACT**

*The regularly expanding number of vehicles has prompted expanding sought after for oil energizes. The earth corruption and exhaustion of petroleum derivatives are another motivation to look through the substitution of this non-renewable energy source. Biodiesel can turn into an appealing decision since it is sustainable, non-harmful, ecological cordial. The target of the current examination work is to research the utilization of Jatropha biodiesel (JB) and fuel received from from pyrolysis of waste wood (WPO) in diesel motor as a substitution of diesel in certain sum. The WPO (10, 20, 30, and 40% by volume) were mixed with JB and tests have been led in a, four stroke, air cooled diesel motor. The brake thermal efficiency of the blend was discovered to be lower than diesel. Nonetheless, hydrocarbon emission and smoke obscurity were discovered to be lower with blend (up to 10%) than diesel activity. The nitric oxide emission of blend was higher than diesel. Considering similar motor execution and decrease in the vast majority of the motor emanations, it very well may be reasoned that mix which contained 90% JB and 10% WPO can be utilized as a possible fuel for diesel motor activity with no motor change.*

**Keywords:** *Compression Ignition Engine; Performance; Emission; Pyrolysis*

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## 1. Introduction

The mechanical insurgency and expanded populace in the last two centuries have brought about an expanded utilization of fossil powers. Especially, interior ignition (IC) motors were worked with the oil-based powers. This brought about expanded degree of carbon dioxide ($CO_2$) in nature essentially during the most recent thirty years. $CO_2$ is one of the ozone harming substances (GHG) that causes a worldwide temperature alteration. The other GHG emanations incorporate CO, NOx, water fume and methane. Between the years 1970 and 2004, the GHG emanations expanded at a normal of 1.6% every year, with $CO_2$ emanations from the utilization of petroleum derivatives developing at the pace of 1.9% every year [1-3]. The aggregate discharges toward the finish of year 2019 were assessed to be 49.5 GT, furthermore, likeness carbon dioxide.

The landfills associated with the municipal and industrial wastes, also contribute to the GHG emissions. If the landfills are minimized by converting them into useful energy, then the source of GHG emissions can be reduced to a great extent. Among the industrial wastes, disposed tyres, plastics and oils, and refrigerants are the main contributors of GHG emissions [4]. The used oil, a contributor to industrial waste includes brake fluids, and hydraulic, transmission, motor, crank case, gear box, synthetic and transformer oils. Such oils can be recycled and used in various ways. The first way is to change the original properties of the oil. The second way is to recover the heat energy available in it. Some of the researchers have converted such waste organic substances into useful energy for IC engine applications [5-6]. The burning of waste wood chips also contributes GHG gases in the environment.

Clean fuel for transportation and power generation is the worldwide requirement for environment protection and sustainable development. The transportation sector mainly depends on petroleum fuels resulting to economic and environmental consequences. Global climate changes due to carbon dioxide ($CO_2$) emission which motivates a vigorous policy debate on alternative source of energy for the light duty vehicle transportation sector. With the increase in use and the depletion of fossil fuels will create a big problem in front of whole world in the coming decade. The numerous biomass-based feed stocks can be used to generate alternate energy which may act as extender or a complete replacement of fossil fuels [7]. This will help very significantly in.

Among the non-edible seeds produced in India, Jatropha is the most preferred because of its high oil content and biodiesel yield [8]. The research works related to the use of biodiesel obtained from Jatropha oil in diesel engines established different results. However, the biodiesel production from Jatropha has a limited scope, due to its lesser availability and collection of oil seeds, as of today. The government of India has already launched a biodiesel programme in the year 2003, to increase biodiesel production. As the availability of Jatropha oil and oil seeds is found to be less at this point of time, a certain percentage of biodiesel can be replaced by some other second generation biofuels [9-11].

In the current study fuel derived by pyrolysis of waste tire and Jatropha biodiesel are used for the replacement of diesel fuel by some percentage. The experiments were carried out in a naturally aspirated, single cylinder, four stroke, air cooled, direct injection (DI) diesel engine with a rated power of 4.4 kW at a constant speed by using different fuel blends. The results were analyzed in terms of performance parameter such as brake thermal efficiency and emissions of hydrocarbon, carbon monoxide, oxides of nitrogen, smoke etc. and compared with those of diesel operated engine.

## 2. MATERIALS AND METHODS

The Jatropha biodiesel (JB) was produced by the tranesterification process which is known as the most efficient process of converting oil into biodiesel. Tranesterification process is also known as alcoholysis and this process is used worldwide for reducing the viscosity of vegetable oils. The transesterification reaction using heterogeneous catalyst potassium impregnated zinc oxide (60K/ZnO) was conducted in this study for conversion of Jatropha curcas oil into biodiesel. The designated amount of catalyst was dispersed into methanol at 35-40 ºC for 15 min using the same experimental set up.

For the present investigation, wastewood derived fuel (WPO) was bought from a recycling plant located in Rajasthan, India. The plant's one batch capacity is 10 Ton. High temperature required for Pyrolysis is obtained by burning of biomass at combustion chamber. Air required for burning was supplied through external blower from bottom of combustion chamber. Flue gases escaping out from combustion chamber are made to circulate outside the pyrolytic chamber and finally released to atmosphere through chimney. Firstly the biomass is burnt to produce desired temperature of 400-700 °C at the surface of combustion chamber. When steady temperatures are attained waste tire is made to fall through the outside surface of combustion chamber with the help of pusher mechanism. Waste tire coming in contact with hot surface melts on outside surface of combustion chamber, cracking occurs and vapors escape to the top of pyrolytic chamber.

The present study is focused to analysis the effect of fuel derived by pyrolysis of waste wood (WPO) blended with JB and diesel in four different percentages as test fuels, on the performance and emission characteristics of a direct injection (DI) diesel engine. The WPO and JB at low percentages (5-20% at regular intervals of 5% on a volume basis), was blended with diesel, to get the fuel blends for the investigation. The designations of the test fuels and their compositions used in this study are given below.

| **Fuel** | **JB (by volume)** | **WPO (b y volume)** | **Diesel (by volume)** |
|---|---|---|---|
| Diesel | - | - | 100% |
| JB | 100% | - | - |
| B10 | 90% | 10% | - |
| B20 | 80% | 20% | - |
| B30 | 70% | 30% | - |
| B40 | 60% | 40% | - |

## 3. Experimentation

The test was carried out on a single cylinder, four stroke, naturally aspirated, air cooled, DI diesel engine which has a maximum power out of 4.4 kW. The test engine specifications are provided in Table 1. For loading on the test engine an eddy current dynamometer is coupled to engine with the help of load cell. The engine is interfaced to a control panel, which is connected to a computer. The inputs obtained from different instruments are interfaced to a computer through an analog and digital converter card PCI-1050 which is mounted on the motherboard. A data acquisition system (DAS) integrated with a computer received data from different instruments which is then processed and displayed on the monitor.

**Table 1 Engine specifications**

| | |
|---|---|
| Type | Kirloskar TAF1 Vertical diesel engine |
| No. of cylinder | 1 |
| Type of injection | Direct |
| Rated power at 1500 rpm, kW | 4.41 |
| Bore, mm | 87.5 |
| Stroke, mm | 110 |
| Compression ratio | 17.5 |
| Displacement volume, litres | 0.662 |
| Fuel injection timing bTDC, °CA | 23 |
| Number of injector nozzle holes | 3 |
| Nozzle-hole diameter, mm | 0.25 |
| Inlet valve opening bTDC, °CA | 4.5 |
| Inlet valve closing aBDC, °CA | 35.5 |
| Exhaust valve opening bBDC, °CA | 35.5 |
| Exhaust valve closing aTDC, °CA | 4.5 |
| Type of fuel injection | Pump-line-nozzle injection system |
| Connecting rod length, mm | 220 |

**4. Results and Discussion**

This section discusses the results of the performance and emission parameters obtained from the test engine run on diesel, JB and different JB-WPO blends.

**4.1 Brake Thermal Efficiency**

The variety of hydrocarbon (HC) discharge for diesel, JB and diverse test fuel mixes is appeared in Fig. 3. It is seen that hydrocarbon outflow increments with the expansion in level of WPO in the diesel-JB-WPO mixes. The HC emanation is least for JB and it was around 18 ppm at full burden activity. This can be because of oxygen particle present in biodiesel [15]. The most noteworthy estimation of HC outflow was gotten with B20 mix and was seen to be 31 ppm. Yet, the expansion of the tire determined fluid rate brings about higher HC emanation. This is because of the way that WPO has higher fragrant substance, and thus may bring about deficient ignition and more HC outflow for B15 and B20 contrasted with the other test energizes utilized in this investigation. The HC esteems for diesel, JB, B5, B10, B15 and B20 23, 18, 19, 21,25 and 31 ppm are at full burden.

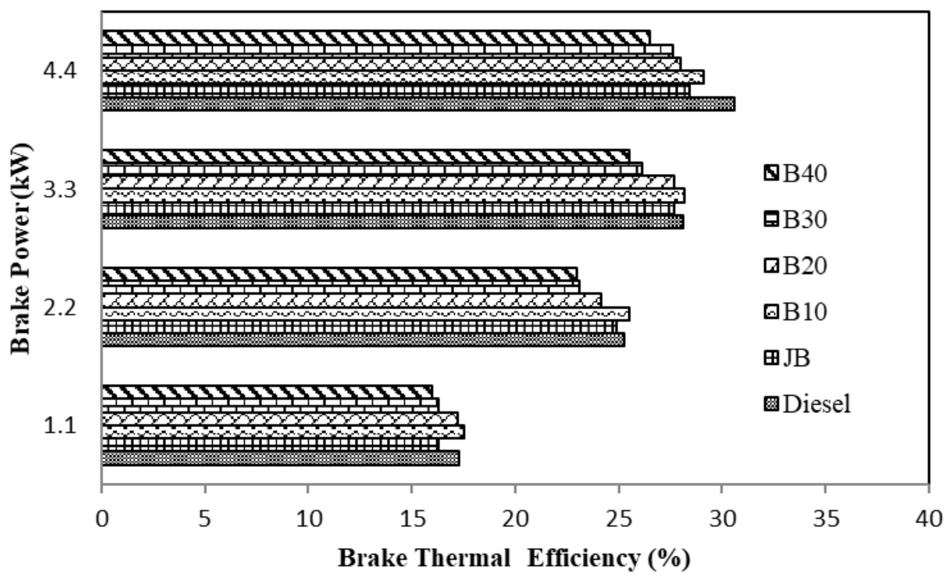


**Fig.1 BTE vs BP**

The poor atomization of test fuels due to the higher viscosity may also be one of the causes for lower brake thermal efficiency than that of diesel. Among blends B20 produces highest brake thermal efficiency.

**4.2 Carbon Monoxide Emission**

The carbon monoxide (CO) discharge attributes of the motor sudden spike in demand for diesel and distinctive test fuel mixes is introduced in Fig. 2. It is realized that the pace of CO discharge is a component of the unburned fuel accessibility and blend temperature, which controls the pace of fuel disintegration and oxidation. Within the sight of adequate oxygen, the CO emanation is changed over into carbon dioxide outflow [13]. The estimation of CO discharge at full burden for the diesel, JB, B5, B10, B15 and B20 mix was discovered to be 0.044, 0.035, 0.037, 0.04, 0.046 and 0.052%. The CO emanation for the JB, B5 and B10 is barely lower than those of diesel fuel. This could be because of the way that JB contains overabundance oxygen which helps for better burning. At the point when the level of tire determined fuel increments past 10%, the CO discharge increments definitely. This may be due presence of aromatic content which results in incomplete combustion and may lead to higher CO emission [14].

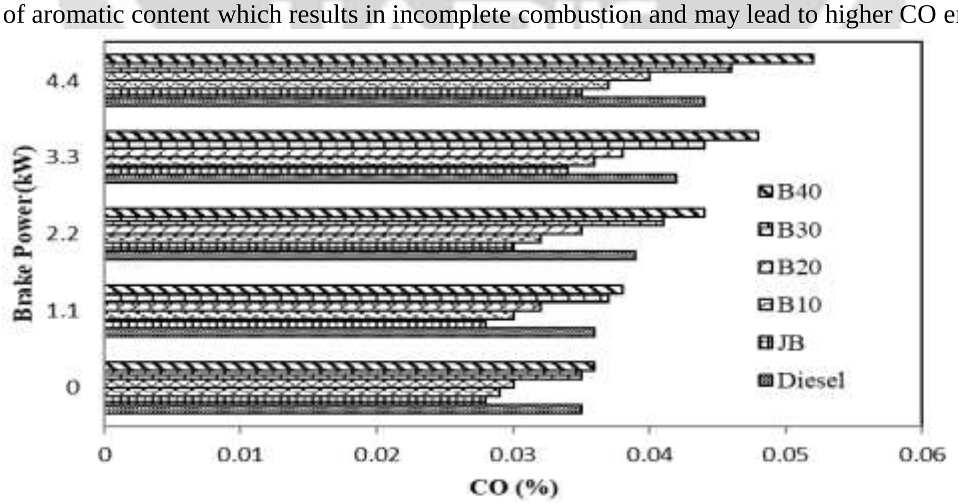


**Fig.2 Variation of carbon monoxide emission with brake power**

### 4.3 Hydrocarbon Emission

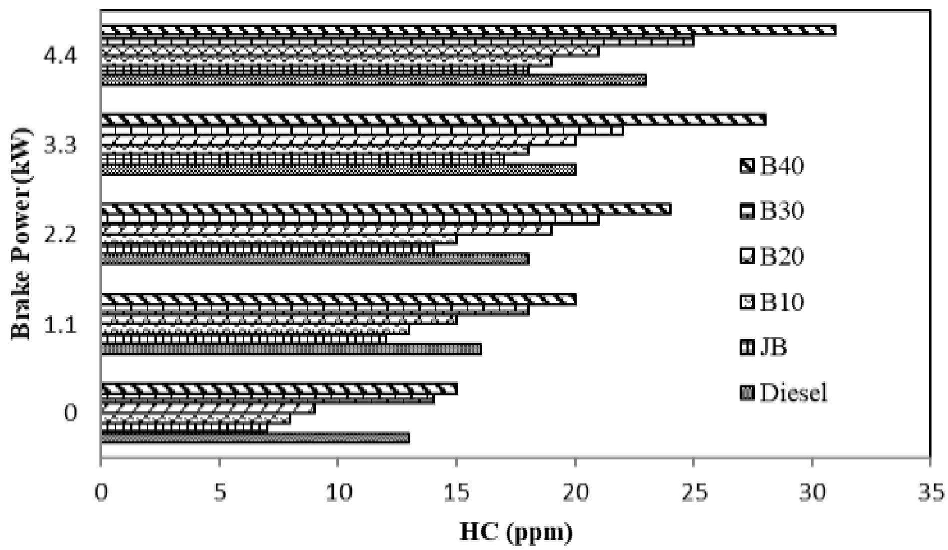


**Fig.3 Variation of the unburnt hydrocarbon emission with brake power**

The variation of hydrocarbon (HC) emission for diesel, JB and different test fuel blends is shown in Fig. 3. It is observed that hydrocarbon emission increases with the increase in percentage of WPO in the diesel-JB-WPO blends. The HC emission is lowest for JB and it was about 18 ppm at full load operation. This can be due to oxygen molecule present in biodiesel [15]. The highest value of HC emission was obtained with B20 blend and was noticed to be 31 ppm. But the addition of the tire derived liquid percentage results in higher HC emission. This is due to the fact that WPO has higher aromatic content, and hence may result in incomplete combustion and more HC emission for B15 and B20 compared to the other test fuels used in this study. The HC values for diesel, JB, B5, B10, B15 and B20 23, 18, 19, 21,25 and 31 ppm are at full load.

### 4.4 Nitric Oxide Emission

The nitric oxide (NO) emission characteristics of the diesel and different test fuel blends derived engine at different load conditions are presented in Fig.4. It can be seen that the NO emission concentration increased with the load for all the test fuels.

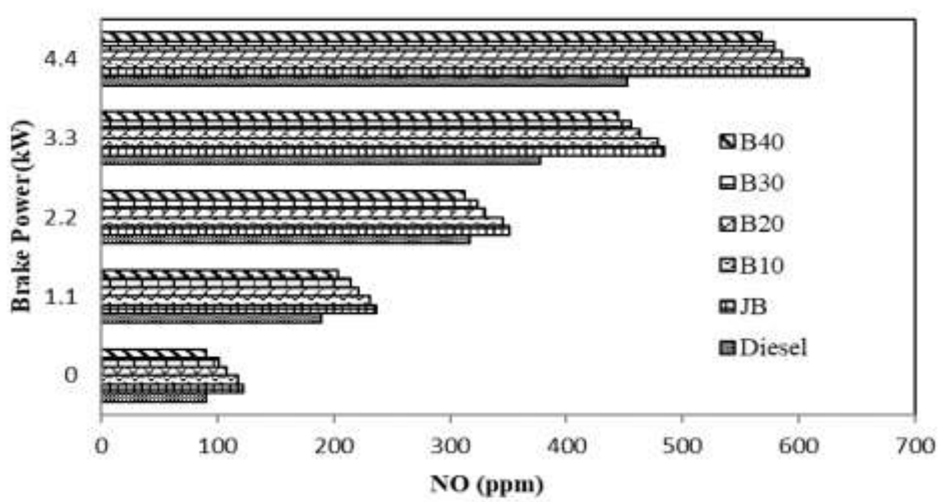


**Fig.4 Variation of the NO emission with brake power**

This is due to the fact that, because with increasing load, the temperature prevailing in the combustion chamber increases [16-17]. The NO emission form engine exhaust is highly dependent on oxygen concentration and combustion temperature. The JB has about 11% oxygen molecule which is the major cause of higher NO emission for this fuel compared to all other test fuel used in this study. While increasing the WPO percentage in the blend, the NO emission decreases, because of lower heat release rates than that of JB. The values of NO emission for diesel, JB, B10, B20, B30, and B40 are by about 433, 498,550, 601, and 658 ppm respectively, at full load operation.

**5 Conclusions**

A single cylinder, four stroke, naturally aspirated, air cooled, DI diesel engine was operated successfully using diesel-JB-WPO blends. The accompanying ends are made dependent on the test results.

- The brake warm proficiency of the motor was most noteworthy for the diesel and among various mix B10 gave higher brake warm effectiveness. At full burden, the brake warm proficiency is nearly the equivalent, i.e., 29.9% and 30.8% for B10 and diesel individually, at full load.
- The CO and HC emission were lower by about 9%, 19% separately for B10, contrasted with diesel at full burden.
- Nitric oxide emission was higher by about 21% for B10 in examination with diesel at full burden.
- On the entire it is finished up, that the B10 mix can be utilized as fuel in a diesel motor straightforwardly, with no motor alteration. The B10 gives the ideal outcome, contrasted with different mixes. The outcomes from the analyses demonstrate that B10 mix is acceptable substitute for diesel fuel.

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