

# Investigations on Combustion Characteristics of Compression-Ignition Diesel Engine with Controlled Atomisation Using Bio-Diesel

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**ABSTRACT:** In India the depletion of Fossil fuel reserves is observed due to increase in consumption. With this environment pollution is also a serious problem, which should be addressed immediately. Even today in major sectors like Agriculture, Industries, Power etc., Diesel fuel is a major source of energy. There is a need to search for substitute fuel which will reduce the dependence on diesel fuel. From the previous researchers it is learnt that biodiesel is one of the prominent substitute fuel for diesel fuel. However some of properties pertaining to biodiesel are inferior to diesel properties. Therefore, in this work an attempt is made for better combustion of bio-diesel by injecting it at various pressures and with different numbers of nozzle holes. In this work, Fuel injection pressure and the nozzle design parameters such as nozzle holes, nozzle diameter etc. are varied to enhance the performance of engine. The experiments are carried out on a single cylinder, four stroke, vertical, water cooled, direct injection, Kirloskar make CI engine using diesel and Animal Tallow biodiesel. The performance characteristics such as brake thermal efficiency, specific fuel consumption, indicated thermal efficiency, mechanical efficiency etc. are evaluated. The results indicate that the brake thermal efficiency for animal tallow biodiesel is higher with 3 hole nozzle at 180 bar fuel injection pressure, compared to diesel fuel with the standard test setup.

**KEYWORDS:** CI Engine, Biodiesel, Nozzle, Fuel injection pressure, Animal Tallow biodiesel.

## I. INTRODUCTION

India is one of the fastest developing countries with a stable economic growth. Fuel consumption is directly proportionate to the demand. India depends mainly on imported fuels due to lack of fossil fuel reserves and it has a great impact on economy. India has to look for an alternative for alternative fuels in order to sustain the growth rate. Bio-diesel is a promising alternative compared to other alternative fuels for our Diesel needs. With vast vegetation and land availability, certainly bio-diesel is a feasible source of fuel for Indian conditions. Recent studies and research have made it possible to extract bio-diesel at economical costs and quantities. It can be observed that the efficiency of the engine increases by the utilization of Bio-diesel. Therefore biodiesel will have a great impact on Indian economy. Diesel engine plays a crucial role in the field of power, propulsion and energy. The diesel engine is more efficient than the petrol engine, since the spark –ignition engine consumes more fuel than the compression –ignition engine. The fuel injection system is the most essential component in the working of CI engine. The engine performance, power output, economy etc. is greatly dependent on the effectiveness of the fuel injection system. The fuel injection system plays an important role in the combustion process. The fuel injection system in a direct injection diesel engine is to achieve a high degree of atomization for better penetration of fuel in order to utilize the full air charge and to promote the evaporation in a very short time and to achieve higher combustion efficiency. A large number of studies have shown

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that biodiesel is one of the promising renewable, alternative and environmentally friendly bio fuels that can be used in diesel engine. Therefore the objective of this study is to investigate the performance and combustion characteristics of CI engine running with biodiesel.

In this experimental investigation, an alternative fuel such as animal tallow biodiesel has been used instead of diesel fuel in a compression ignition engine. The animal tallow has been collected from a local commercial supplier. Its usability was investigated as pure biodiesel and its blends with diesel fuel. Animal fats are highly viscous and mostly in solid form at ambient temperature because of their high content of saturated fatty acids. The high viscous fuels lead to poor atomization of the fuel and result in incomplete combustion. Transesterification and emulsification are two main solutions that have appeared as effective methods for using animal fats in diesel engine. The fuels produced by these methods from animal fats and vegetable oil reduce pollutant emissions and improves combustion.

Using biodiesel, optimized blends of biodiesel and diesel can help reduce some significant percentage of the world's dependence on fossil fuels without modification of CI Engine. For example using optimized blend of biodiesel and diesel instead of the conventional diesel fuel significantly reduces the exhaust emissions particulate matter (PM), carbon monoxide (CO), sulfur oxides (Sox) and unburned hydrocarbons (HC).

## II. TEST ENGINESPECIFICATIONS AND EXPERIMENTAL PROCEDURE

The experiments were carried out in a Kirloskar make, single cylinder, direct injection, 4-stroke stationary diesel engine and are shown in figure 2.1. The specification of the experimental set-up is given in Table 2.2.

### A. TEST ENGINE SPECIFICATIONS

Number of cylinders	1
Number of strokes	4
Fuel	Diesel
Rated Power	5.2 KW @ 1500 RPM
Cylinder bore	84.5mm
Stroke Length	110mm
Compression Ratio	16.5:1
Dynamometer arm length	185mm
Dynamometer Type	Eddy Current
Type of cooling	water cooled
<b>Table 2.1 Specifications of Compression Ignition Engine</b>	

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## B. TEST ENGINE SETUP

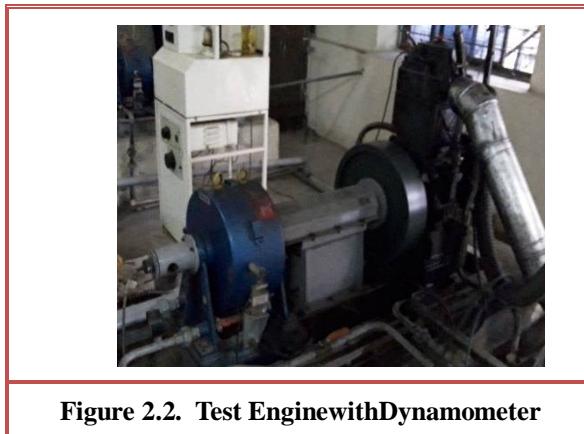


Figure 2.2. Test Engine with Dynamometer

## C. EXPERIMENTAL PROCEDURE

The following procedure is adopted in carrying the experiments using Diesel Fuel and Animal Tallow Bio-Diesel.

### 2.3.1. Experimental procedure with Diesel Fuel

For experimentation, the compression ignition engine has to run at a rated speed and is allowed to obtain thermal equilibrium condition. Then experiments are conducted by varying percentage of loads like no load, 10%, 20%, 30%, 40%, 50%, 60% and 70% at a rated speed. At each load of operation the inlet air flow rate, the ambient temperature, the exhaust gas temperature, the cooling water flow rate and their operating temperature are noted.

The engine is first started by using Diesel as a fuel at injection pressure of 180 bars with 3 hole nozzle. The input parameters are noted and performance parameters like as Brake Power (BP), Brake thermal efficiency ( $\eta_{B.th}$ ), Specific Fuel consumption (SFC), are evaluated. These results are the standard results and are used for comparison of performance parameters of biodiesels with different fuel nozzles and different injection pressures.

### 2.3.2. Experimental procedure with Alternate Fuel

The following sets of readings are taken with alternate fuel:

3 hole nozzle with injection pressures of 180 bar, 200 bar, and 220 bar

4 hole nozzle with injection pressures of 180 bar, 200 bar, and 220 bar

5 hole nozzle with injection pressures of 180 bar, 200 bar, and 220 bar

The readings are noted separately and performance parameters are evaluated. The performance parameters of Diesel fuel at 180 bar with 3 hole nozzle used as standard readings. The performance parameters of biodiesel with the above injection pressures and nozzle configurations are then compared with above standard parameters. The engine is sufficiently warmed up and stabilized before taking all the readings.

## III. RESULTS AND DISCUSSION

The experimental investigations are carried out in a Kirloskar make, single cylinder, and direct injection, 4-stroke stationary diesel engine using diesel as a conventional fuel and animal tallow biodiesel as an alternative fuel. The achieved experimental results are analyzed and discussed in this section.

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## 3.1. Engine Performance Parameters at full speed by using Diesel and Biodiesel with different Nozzle holes and Injection pressures

The results are plotted for Diesel fuel and Biodiesel using Different Nozzle holes and Injection pressures for Brake Thermal Efficiency, Specific Fuel Consumption, Indicated Thermal Efficiency and Mechanical Efficiency.

### 3.1.1 Brake Thermal Efficiency

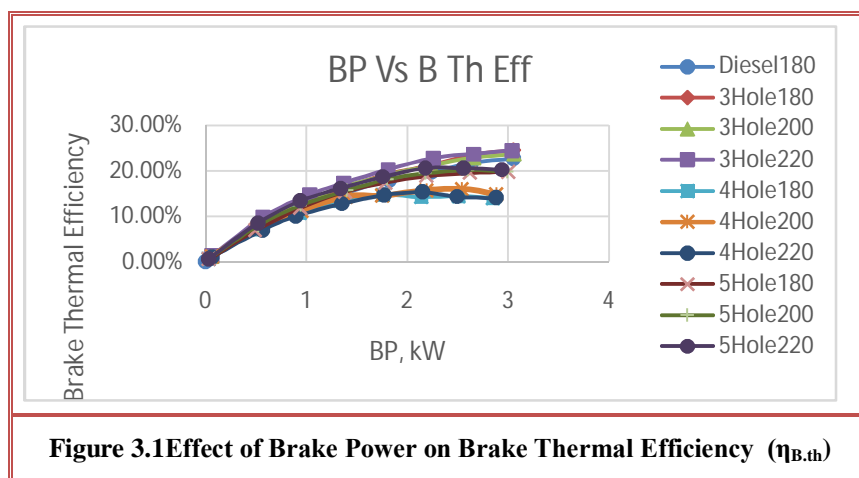


Figure 3.1 Effect of Brake Power on Brake Thermal Efficiency ( $\eta_{B.th}$ )

From fig 3.1, Brake thermal efficiency increases with increase an engine loads with rated speed. From the graph it is concluded that the maximum Brake thermal efficiency is obtained for 24.52% at 11.9 kg load at 180 bar pressure with 3hole nozzle. The Brake thermal efficiency at 220 bar pressure 3hole nozzle and 200 bar pressure with 3hole nozzle is higher than 22.80% diesel 180 bar pressure.

### 3.1.2 Specific Fuel Consumption (SFC)

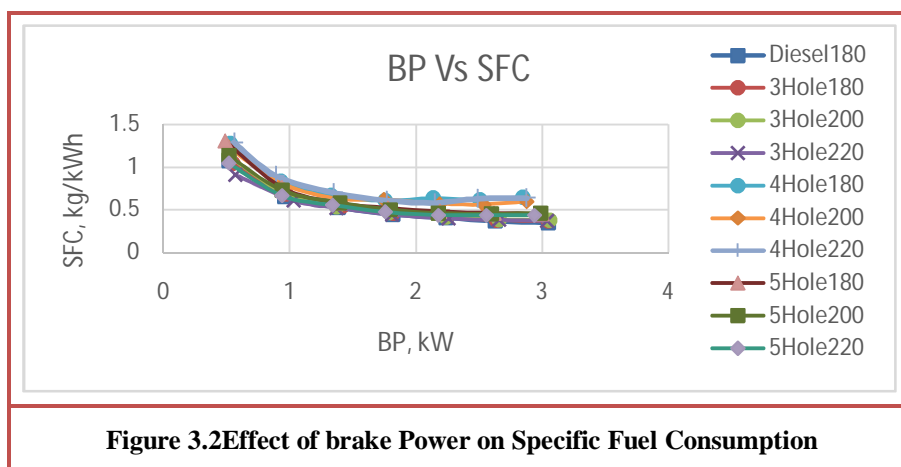


Figure 3.2 Effect of brake Power on Specific Fuel Consumption

Specific fuel consumption is varies with different loading conditions and different injection pressures as shown in fig 3.2. The Specific fuel consumption obtained for diesel is 0.35 kg/kwh and 0.37 kg/kwh for animal tallow biodiesel at 180 bar using 3hole nozzle. The value is slightly difference between diesel fuel than that of animal tallow

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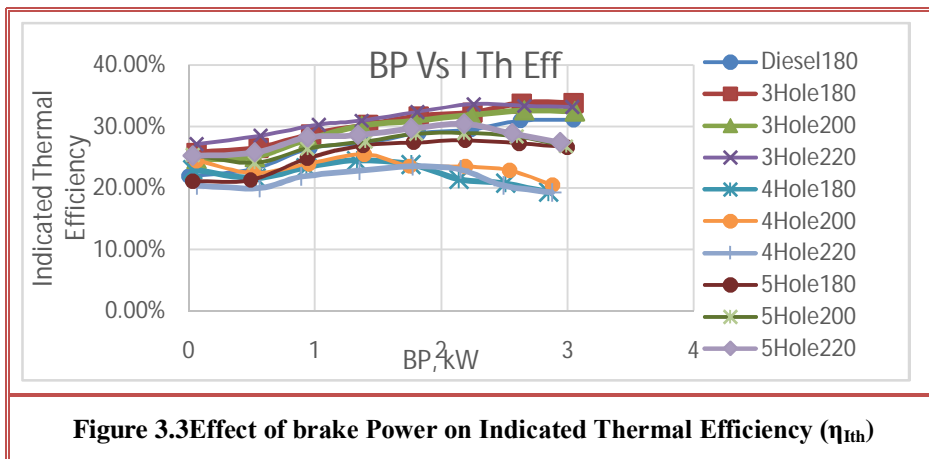
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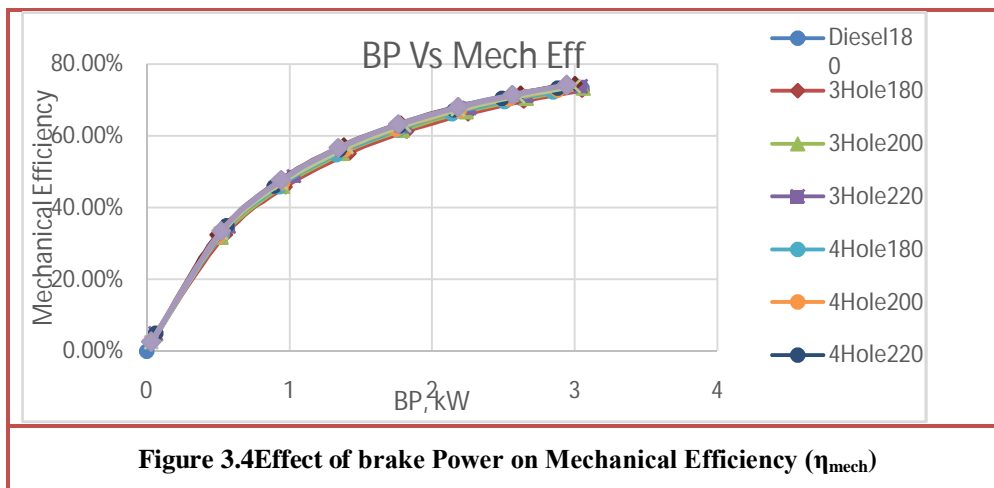
biodiesel fuel. Finally it is concluded that Specific fuel consumption is decreasing an increasing brake power.

### 3.1.3 Indicated Thermal Efficiency ( $\eta_{Ith}$ )



From fig 3.3, Indicated thermal efficiency increases with increase in brake power. From the graph it is observed that the maximum Indicated thermal efficiency obtained for biodiesel is 33.84% at 180 bar pressure with 3hole nozzle. The Indicated thermal efficiency value at 220 bar pressure with 3hole nozzle and 200 bar pressure with 3hole nozzle is higher than diesel 180 bar pressure.

### 3.1.4 Mechanical Efficiency ( $\eta_{mech}$ )



From fig 3.4 Mechanical efficiency increases with increase in brake power. From the graph it is observed that maximum Mechanical efficiency is obtained for 74.62% at 180 bar pressure using 5hole nozzle. The remaining parameters of 200 bar and 220 bar pressure using 3hole nozzle and 180 bar, 200bar and 220 bar pressure using 4hole nozzle values are negligible difference compared to 73.32% diesel at 180 bar pressure. Finally it is concluded that Mechanical efficiency increases with increase in brake power

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## IV. CONCLUSION

Experiments are carried out to investigate the compression ignition engine performance by using Diesel at 180 bar with 3 Hole Nozzle and animal tallow biodiesel as an alternate fuel with at 180 bar, 200 bar, 220 bar using 3 Hole Nozzle, 4 Hole Nozzle, 5 Hole Nozzle respectively. The obtained data from experiments has been analysed and subsequently the following important conclusions have been derived:

- ✓ The Brake Thermal Efficiency for animal tallow biodiesel at 180 bar pressure with 3 hole nozzle is 24.57% and that of the Diesel is 22.80%.
- ✓ The Specific Fuel Consumption for animal tallow biodiesel is 0.37 kg/kWh and that of Diesel is 0.35 kg/kWh at the above conditions. It is also noted that the specific fuel consumption for 4 hole nozzle at 180 bar pressure is 0.65 kg/kWh.
- ✓ The Mechanical Efficiency for animal tallow biodiesel at 180 bar pressure with 5 hole nozzle is 74.62% and that of the Diesel is 73.32%.

The good fuels should have moderate Cetane number, high calorific value, lesser emissions when burned, degradable, sustainable and should readily be available. All these properties are met by animal tallow methyl ester. To meet the present stringent environmental conditions, engines should have the best combination of Fuel Nozzle fitted and the appropriate Injection Pressure selected.

Finally it is concluded that the combined effect of biodiesel and the selection of proper Fuel Injector Nozzle holes and Fuel Injection pressure provided comparable results on engine performance with that of engine fuelled by diesel at standard test conditions.

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