

# Influence of Injection Timing on Performance and Emission Characteristics of Simarouba Biodiesel Engine

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**Abstract-** Efforts are being made throughout the World to reduce the consumption of liquid petroleum fuels wherever is possible. Biodiesel is recently gaining prominence as a substitute for petroleum based diesel mainly due to environmental considerations and depletion of vital resources like petroleum and coal. According to Indian scenario, the demand for petroleum diesel is increasing day by day hence there is a need to find out an appropriate solution. This study investigates influence of injection timing of 20% blend simarouba biodiesel on performance and emission characteristics. The effect of varying injection timing was evaluated in terms of thermal efficiency, specific fuel consumption, carbon monoxide, hydrocarbons and oxides of nitrogen. By retarding injection timing brake thermal efficiency can be improved of S20.

**Index Terms-** injection timing, simarouba, biodiesel

## INTRODUCTION

The recent survey on the world energy consumption highlights that a major portion of the total energy consumed is derived from the combustion of fossil fuels. Unfortunately, the reserves of fossil fuels, specially the liquid fuels are not unlimited and may exhaust, if not utilized economically, within few decades. Recently, there has been a growing concern about the increasing air pollution caused by the combustion of petro diesel. In addition, depleting resources of conventional fuels has caused an increase in its price. Biodiesel is a renewable fuel which is produced from vegetable oil or animal fat through a chemical process and can be used as either direct substitute, extender or as an additive to fossil diesel fuel in compression ignition engines. The most promising feature of biodiesel is that it can be utilized in existing design of diesel engine with no or very little modifications. It has a proven performance for air pollution reduction. Biodiesel is typically produced through the reaction of vegetable oils or animal fat with methanol or ethanol in the presence of catalyst to yield glycerol as major by product[1] ( biodiesel chemically called methyl or ethyl ester). However, the price of biodiesel is presently more as compared to petro diesel [2]. Higher cost of biodiesel is primarily due to the raw material cost [3]. One non edible biodiesel feedstock is simarouba glauca.

It is commonly accepted that there is some advancement of injection time when biodiesel is used in place of diesel because of its bulk density. The higher bulk density and viscosity transfers the pressure wave through fuel pipe lines faster and an earlier needle lift will lead to advanced injection. Due to the difference in cetane number, it is often suggested that injection timing be retarded to attain more complete combustion of vegetable oil based fuels [4]. Late injection of fuel into the combustion chamber helps in reducing the NO<sub>x</sub> emission of a diesel engine [5]. Evaluation of Simarouba esters indicates its superiority over many other vegetable oils in terms of engine performance, emissions, ease of use and availability. Simarouba glauca belongs to family simarubaceae, commonly known as "The Paradise Tree" or "King Oil Seed Tree", is a versatile multipurpose evergreen tree having a height of 7-15 m with tap root system.

In India, it is mainly observed in Andhra Pradesh, Karnataka and Tamil Nadu etc. It can adapt a wide range of temperature, has the potentiality to produce 2000-2500 kg seed/ha/year ; can grow well in marginal lands/wastelands with degraded soils and therefore considered as a major forest tree. All parts of Simarouba are useful in some way or the other. The plant is also known for its medicinal properties.



Simarouba seeds

An effort is made in this study to evaluate the effect of varying the injection timing on the combustion, performance and emissions of a 5.2 kW engine fuelled with simarouba methyl ester of this oil (S20) for establishing the appropriate injection timing. The aim was to establish the modifications required in small, constant speed, direct injection diesel engines ,so that these can be made to run on Simarouba biodiesel (S20) with better performance and at the same time improve the emissions.

**IDENTIFY, RESEARCH AND COLLECT IDEA**

Biodiesel is produced by the transesterification of vegetable oils with alcohols to produce esters. [6]. Bio-diesel has become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources [7]. Biodiesel has demonstrated a number of promising characteristics, including reduction of exhaust emissions [8]. Although there are many ways and procedures to convert vegetable oil into a Diesel like fuel, the trans-esterification process was found to be the most viable oil modification process [9]. Trans-esterification is the process of using an alcohol (e.g. methanol, ethanol or butanol), in the presence of a catalyst, such as sodium hydroxide or potassium hydroxide, to break the molecule of the raw renewable oil chemically into methyl or ethyl esters of the renewable oil, with glycerol as a byproduct. Glycerol is the major value-added byproduct produced from oil and fat from transesterification reactions performed during biodiesel manufacturing processes.

For a diesel engine, fuel injection timing is a major parameter that affects the performance and exhaust emissions. The state of air into which the fuel injected changes as the injection timing is varied, and thus ignition delay will vary. If injection starts earlier, the initial air temperature and pressure will be lower, so that the ignition delay will increase. If injection starts later (when piston is closer to TDC), the temperature and pressure will be slightly higher, a decrease in ignition delay will proceed. Hence, injection timing variation has a strong effect on the engine performance and exhaust emissions, especially on the brake specific fuel consumption (Bsfc), brake thermal efficiency (BTE) and NOx emissions, because of changing maximum pressure and temperature in the cylinder [10,11].

**STUDIES AND FINDINGS**

**Properties of diesel and simarouba biodiesel**

Property comparison of Diesel and Simarouba bio diesel are shown in table 1

SL.NO.	Characteristics	Diesel	Simarouba 100%	Simarouba 20%(S20)
1	Calorific value (KJ/Kg)	43000	39800	42360
2	Viscosity at 40 <sup>0</sup> C	2.6-5	4.8	3.4
3	Cetane number	50	51	51
4	Flash point (°C)	55	165	70
5	Specific gravity	0.84	0.867	0.8454

**EXPERIMENTAL SET UP, PROCEDURE AND OBSERVATION**

The experiment aims at determining appropriate proportions of biodiesel & diesel for which higher efficiency is obtainable. Hence experiments are carried out at constant speed, comparing the performance of compression ignition engine operated on blends of diesel. The S20 blend is checked under loads 20%,40%,60% and 80% with injection timing 15.1<sup>0</sup>,20.5<sup>0</sup> and 25.5<sup>0</sup>BTDC by constant injection pressure 200 bar and compression ratio 17.5. The samples are prepared by using the 1000 ml measuring jar and a 10 ml graduated test tube.

Fig.1 shows the schematic diagram of the complete experimental setup for determining the effects of waste cooking oil as bio diesel fuel additives on the performance and emission characteristics of compression ignition engine. It consists of a single cylinder four stroke water cooled compression ignition engine connected to an eddy current dynamometer. It is provided with temperature sensors for the measurement of jacket water, calorimeter water, and calorimeter exhaust gas inlet and outlet temperature. It is also provided with pressure sensors for the measurement of combustion gas pressure and fuel injection pressure. An encoder is fixed for crank angle record. The signals from these sensors are interfaced with a computer to an engine indicator to display P-θ, P-V and fuel injection pressure versus crank angle plots. The provision is also made for the measurement of volumetric fuel flow. The built in program in the system calculates indicated power, brake power, thermal efficiency, volumetric efficiency and heat balance. The software package is fully configurable and averaged P-θ diagram, P-V plot and liquid fuel injection pressure diagram can be obtained for various operating conditions.

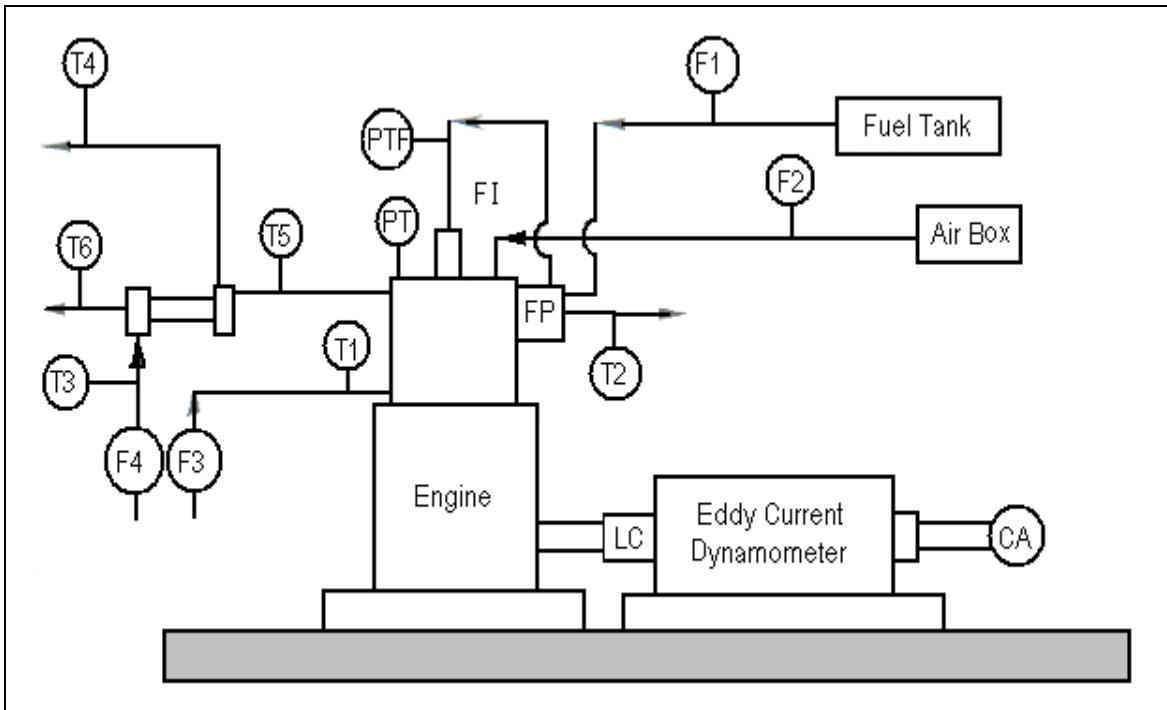


Fig. 3.1 Schematic Diagram of the Experimental Set-up

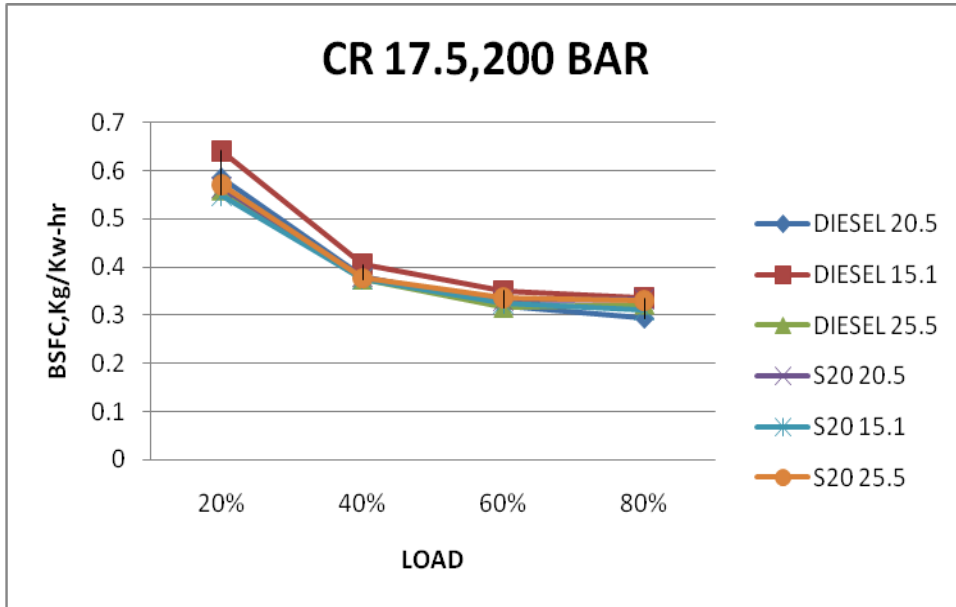
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|-----|--|-----|-----------------------------|
| PT  | Combustion Chamber Pressure Sensor         | F1  | Liquid fuel flow rate       |
| PTF | Fuel Injection Pressure Sensor             | F2  | Air Flow Rate               |
| FI  | Fuel Injector                              | F3  | Jacket water flow rate      |
| FP  | Fuel Pump                                  | F4  | Calorimeter water flow rate |
| T1  | Jacket Water Inlet Temperature             | LC  | Load Cell                   |
| T2  | Jacket Water Outlet Temperature            | CA  | Crank Angle Encoder         |
| T3  | Inlet Water Temperature at Calorimeter     | EGC | Exhaust Gas Calorimeter     |
| T4  | Outlet Water Temperature at Calorimeter    |     |                             |
| T5  | Exhaust Gas Temperature before Calorimeter |     |                             |
| T6  | Exhaust Gas Temperature after Calorimeter  |     |                             |

### ENGINE SPECIFICATIONS

SL.NO	Engine parameters	specification
1	Engine type	TV1(Kirloskar ,four stroke)
2	Rated power	5.2 KW at 1500 rpm
3	Bore	87.5 mm
4	Stroke	110 mm
5	Cubic capacity	661 cc
6	Compression ratio	17.5:1
7	Injection pressure	200 bar
8	Injection timing	20.5 <sup>0</sup> BTDC

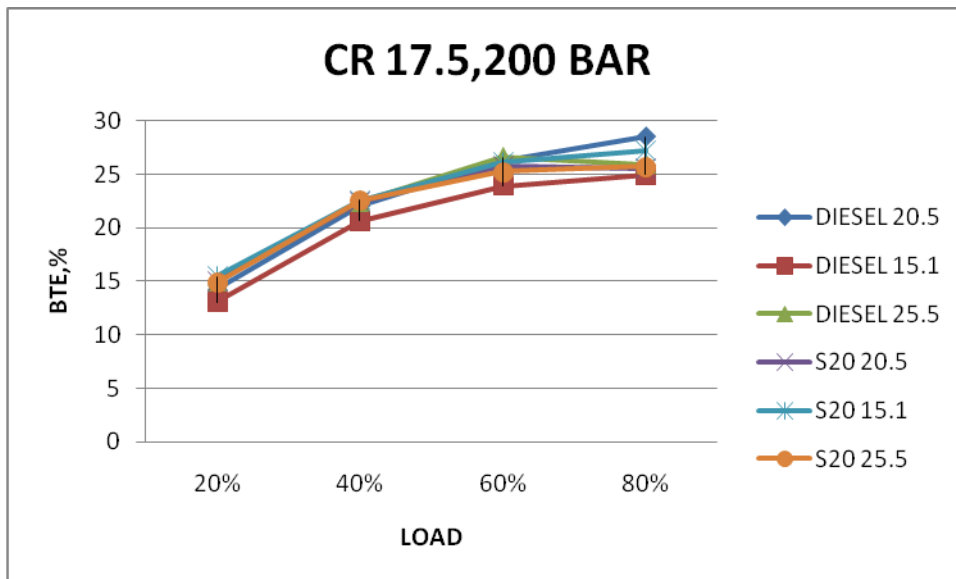
### RESULTS AND DISCUSSIONS

### Brake specific fuel consumption



While retarded injection timing BSFC is more in diesel comparative to S20 biodiesel.

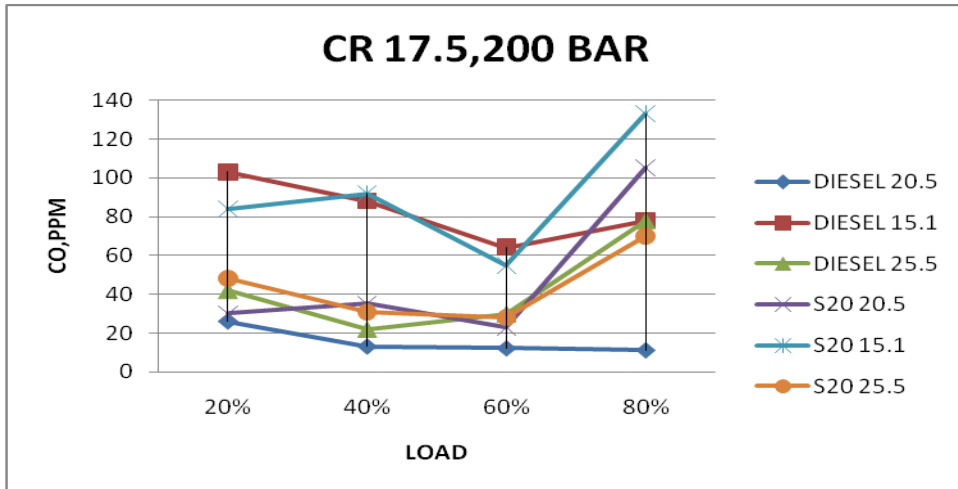
### Brake thermal efficiency(BTE)



Less brake thermal efficiency is obtained while retarded injection timing for diesel. For retarding injection timing S20 give better brake thermal efficiency.

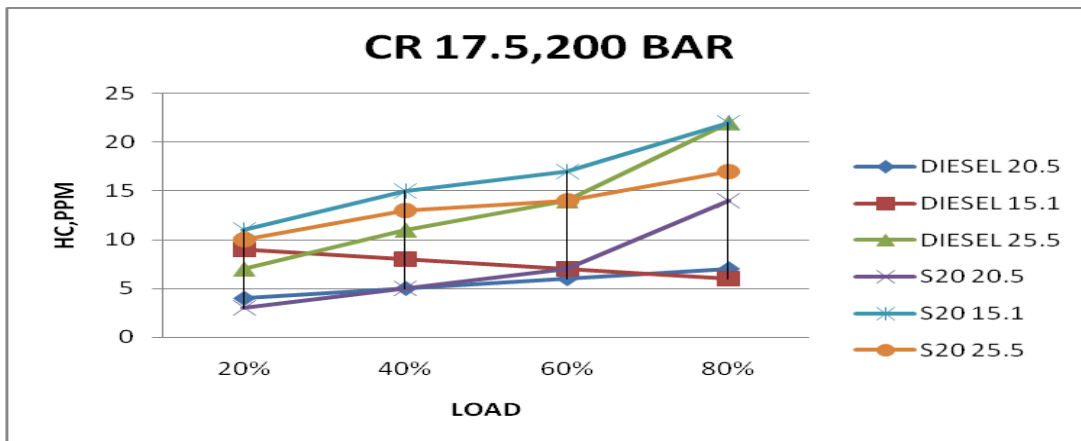
### Carbon monoxide(CO)

Very less carbon monoxide emission for diesel while at standard injection timing  $20.5^0$ .

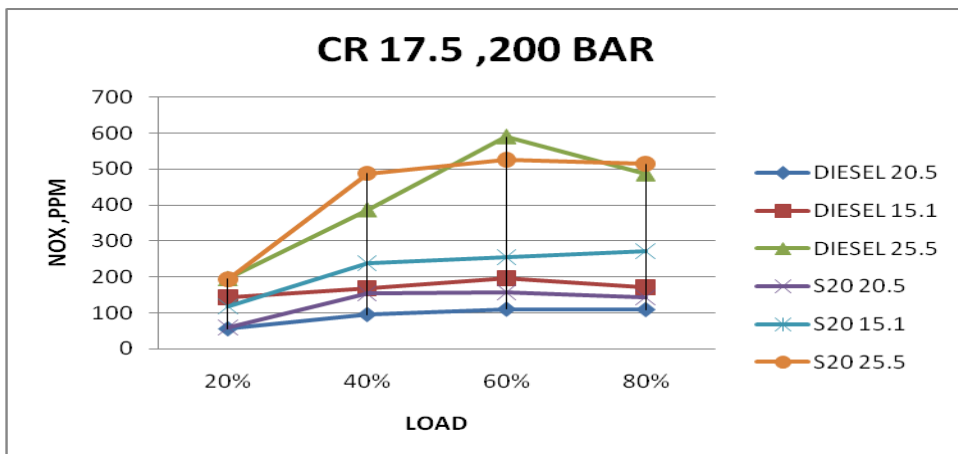


### Hydrocarbons(HC)

Retarding injection timing causes more hydrocarbon emission.



### NOX EMISSION



#### APPENDIX

BSFC-BRAKE SPECIFIC FUEL CONSUMPTION

BTE -BRAKE THERMAL EFFICIENCY

BTDC-BEFORE TOP DEAD CENTRE

CO- CARBON MONOXIDE

HC- HYDROCARBONS

NOX- OXIDES OF NOTROGEN

PPM- PARTS PER MILLENNIUM

S20-SIMAROUBA 20% BLEND DIESEL

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