

Influence of Injection Timing on Performance and Combustion 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 combustion characteristics. The effect of varying injection timing was evaluated in terms of thermal efficiency, specific fuel consumption, heat release rate and peak cylinder pressure. By retarding injection timing brake thermal efficiency can be improved of S20

KEYWORDS: injection timing, simarouba, biodiesel, heat release rate, thermal efficiency

I. 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]. 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 the other. The plant is also known for its medicinal properties 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.

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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.



Fig 1: 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.

II. RELATED WORK

Vishwanath Kasturi, M. C. Navindgi[6] et al conducted experiments on performance and emission characteristics of simarouba biodiesel and its blends on LHR engine. This work includes comparison between LHR engine and normal engine fuelled with blends of simarouba in the proportion of S0, S20, S40 and S100. Results showed that, at maximum load the specific fuel consumption of LHR engine fuelled with biodiesel was higher than LHR engine fuelled with diesel and lower than normal engine fuelled with diesel and biodiesel.. The S20 blend with LHR engine had higher brake thermal efficiency than normal engine. The CO emission in case of LHR engine for S20 blend was lower than normal engine. At full load HC emission levels were decreases for LHR engine fuelled with biodiesel than LHR engine fuelled with diesel and normal engine fuelled with diesel. At higher loads, NOx emission for LHR engine with biodiesel fuel was higher than normal engine with biodiesel.

Mishra S. R., Mohanty M. K., Das S. P [8] et al This paper deals with the transesterification of simarouba glauca oil by means of methanol in presence of potassium hydroxide catalyst at less than 65°C. The results showed that, for simarouba biodiesel kinematic viscosity at 40°C was found to be 4.68 cSt, density 865 kg/m³, flash point 165°C, cloud point 19°C, pour point 14.2°C, carbon residue 0.10% w/w, ash content 0.005 w/w.

Dilip Sutraway et al. [11] in this work they investigated the Effect of Fuel Injection Time on the Performance of CI Engine Using (Simarouba) Biodiesel as Fuel. The results of the experimental investigation indicate that the, with injection timing 20°BTDC, 23°BTDC and 26°BTDC, blend S20 with injection timing 23°BTDC (Normal) shows higher performance and less emissions for all blends at rated load and 220 bar injection pressure.

III. EXPERIMENT AND PROCEDURE

In the study, the selected vegetable oil was transesterified and the major properties were evaluated. Further, the evaluation of the methyl ester was done in a compression ignition engine for combustion and performance at different injection timings.

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Transesterification

The transesterification of the oil sample was carried out in the lab using standard procedures adopted commonly through out the world [5]. As Simarouba oil contains low FFA (less than 5%), methanol with KOH as catalyst was used for transesterification. After separation of glycerol, the ester was water washed to remove un-reacted meth oxide. It was then heated to remove the water traces to obtain clear biodiesel.

The properties of so prepared biodiesel were tested in the laboratory using standard test procedures as per ASTM/BIS and are listed in Table 1. The properties tested were relative density (standard RD bottles of 50 ml capacity), calorific value (adiabatic bomb calorimeter), Kinematic viscosity (Redwood No.1 viscometer), flash point (Pensky-Marten closed cup apparatus).

Sl.no.	Characteristics	Diesel	Simarouba 100%	Simarouba 20% (S20)
1	Relative density	0.84	0.867	0.8454
2	Calorific value	43000	39800	42360
3	Kinematic viscosity at 40 ^o C	2.6-5	4.8	3.4
4	Flash point	55	165	70
5	Cetane number	50	51	51

TABLE 1: Properties of fuel

Experimental set-up

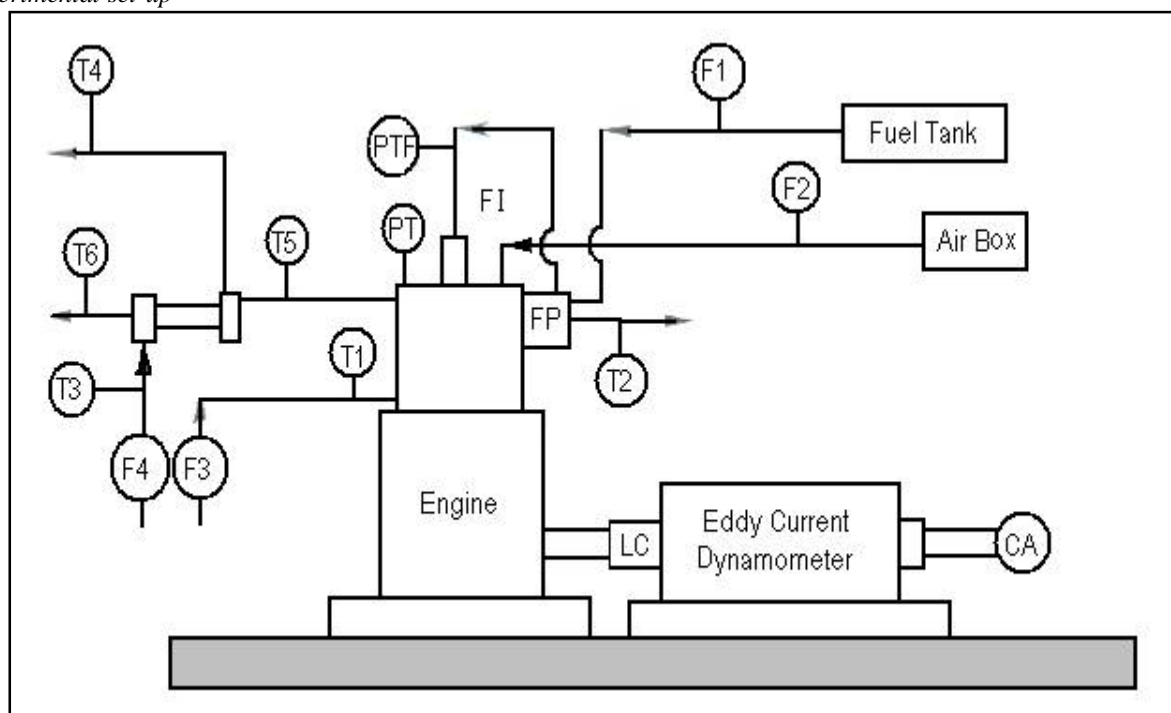


Fig.2 Schematic Diagram of the Experimental Set-up

PTF: Fuel Injection Pressure Sensor
PT : Combustion Chamber Pressure Sensor
FI : Fuel Injector
FP : Fuel Pump
T1 : Jacket Water Inlet Temperature

F2 : Air Flow Rate
F1 : Liquid fuel flow rate
F3 : Jacket water flow rate
F4 : Calorimeter water flow rate
LC : Load Cell

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T2 : Jacket Water Outlet Temperature
 T3 : Inlet Water Temperature at Calorimeter
 T4 : Outlet Water Temperature at Calorimeter
 T5 : Exhaust Gas Temperature before Calorimeter
 T6 : Exhaust Gas Temperature after Calorimeter

CA: Crank Angle Encoder
 EGC: Exhaust Gas Calorimeter

Fig 2 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.

SL.NO	Engine Parameters	Specification
01	Machine supplier	INLAB Equipments. Bangalore.
02	Engine Type	TV1(Kirloskar, Four Stroke)
03	Number of cylinders	Single Cylinder
04	Number of strokes	Four-Stroke
05	Rated power	5.2KW (7 HP) @1500RPM
06	Bore	87.5mm
07	Stroke	110mm
08	Cubic Capacity	661cc
09	Compression ratio	17.5:1
10	Rated Speed	1500 RPM
11	Dynamometer	Eddy Current dynamometer, make SAJ
12	Type of cooling	Water cooling
13	Fuel injection Pressure	200 bar
14	Fuel	Diesel
15	Load Measurement	Strain gauge load cell
16	Speed Measurement	Rotary encoder
17	Temperature Indicator	Digital, PT-100 type temperature sensor
18	Cylinder Pressure Measurement	Piezo-Sensor, range 2000 Psi, make PCB USA
19	Fuel Injection Pressure Measurement	Piezo Sensor, range 5000 Psi, make PCB USA
20	Water flow Measurement	Rota meter

Table 2: Engine specifications

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IV. EXPERIMENTAL PROCEDURE

The engine has a compression ratio of 17.5 and a normal speed of 1500 rpm controlled by the governor. An injection pressure of 200bar and injection timing 20.5°BTDC is used for the best performance as specified by the manufacturer. The engine is first run with neat diesel at loading conditions such as 6.5, 13, 19.5 and 26 N-m. Between two load trials the engine is allowed to become stable by running it for 3 minutes before taking the readings. At each loading condition performance parameters namely speed, exhaust gas temperature, brake power, peak pressure are measured under steady state conditions. The experiments are repeated for S20 diesel blends. Varying injection timing 15.1°BTDC, 25.5°BTDC experiment is repeated. With the above experimental results, the parameters such as total fuel consumption, brake specific fuel consumption, brake mean effective pressure; brake specific energy consumption, brake thermal efficiency are calculated. Finally graphs are plotted for brake specific fuel consumption, brake thermal efficiency with respect to loading conditions for diesel, bio-diesel and its blends. From these plots, performance characteristics of the engine are determined.

V. EXPERIMENTAL RESULTS AND DISCUSSION

The effect of transesterification on major properties of the oil is given in Table 1. The relationships Between independent variables (load and injection timing) and dependent variables are shown in the Figures and the overall effects of injection timing on combustion, engine performance are discussed in this section.

Effect on brake thermal efficiency

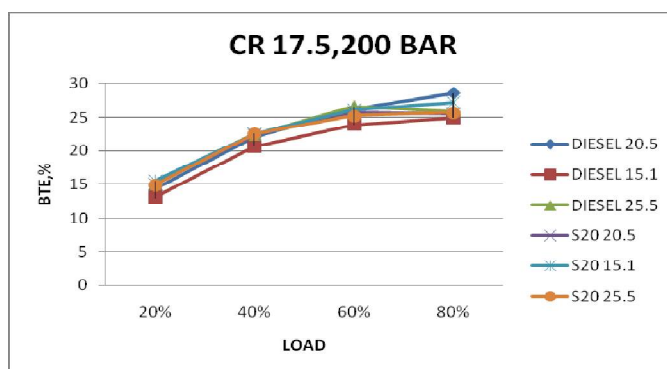


Fig 3: Brake thermal efficiency V/s load at different injection timing for diesel and S20

The effect of injection timing on engine performance is significant. It can be seen from the Figure 3 that retarding the injection timing for S20 by 5° increases the thermal efficiency remarkably. The advancement of injection is not desirable as it leads to drop in thermal efficiency of the engine. With S20 as fuel, the thermal efficiency at 80% load increases from 25.48% to 27.26% on retarding by 5°. About 7% improvement in thermal efficiency is obtained by retarding the injection timing by 5°

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Effect on brake specific fuel consumption

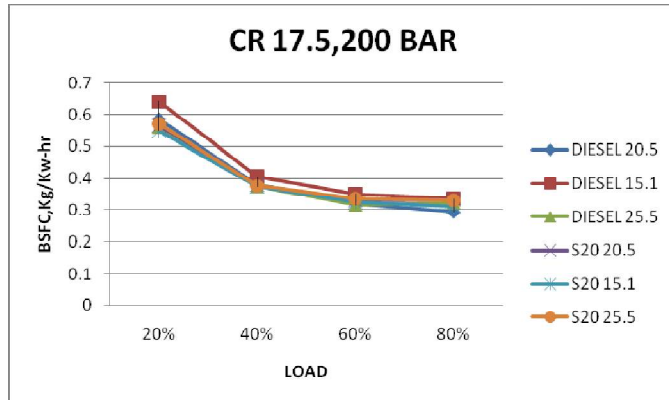


Fig 4: Brake specific fuel consumption V/s load at different injection timing for diesel and S20

The brake specific fuel consumption is also affected by changes in the injection timing corresponding to the changes in thermal efficiency. With the advancement of the injection timing, the specific fuel consumption increases whereas retarding leads to improvement (Figure 4). With S20 as fuel, the BSFC value decreases to 0.332 from 0.311 Kg/kW-hr on retarding the injection by 5° degrees. On retarding the injection, the delay period increases but fuel delivery to cylinder reduces with a higher mean effective pressure in the cycle maintaining the power, thereby reducing the specific fuel consumption.

Effect on exhaust temperature

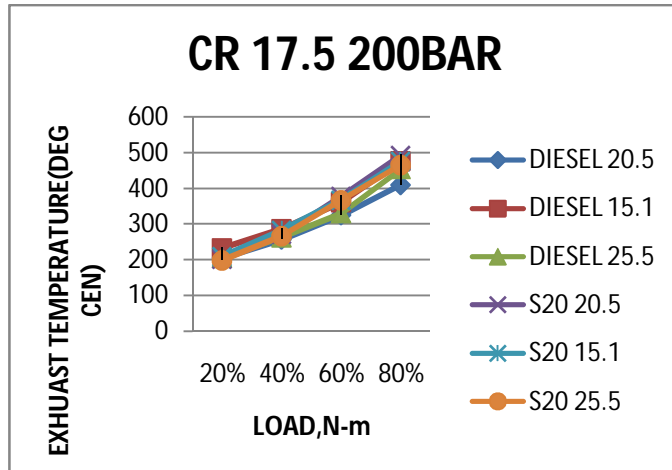


Fig 5 : Exhaust gas temperature V/s load at different injection timing for diesel and S20

The trend line for exhaust temperature with different injection timings indicates increase in temperature of exhaust gases with retarded injection (Figure 5). As the combustion is delayed and more of the heat is released in mixing controlled combustion regime, greater amount of heat goes with exhaust gases. With advanced injection, wall heat transfer is more due to earlier combustion in the cycle leading to lower exhaust temperature.

Effect on cylinder pressure and net heat release rate

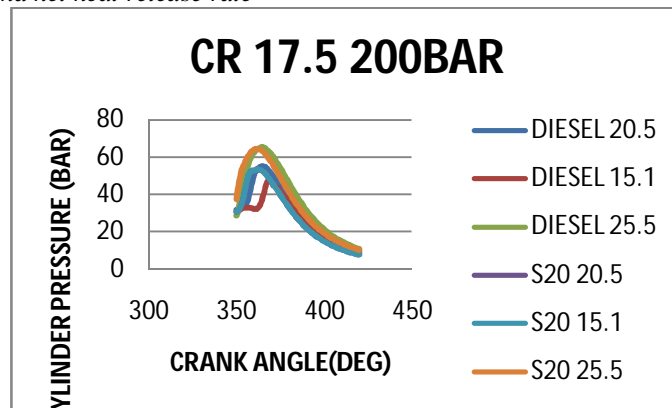


Fig 6 : Cylinder pressure V/s crank angle at different injection timing for diesel and S20

Figure 6 represents the effect of injection timing on cylinder pressure and net heat release rate at 60% load conditions. With changes in injection timing, as expected, the in-cylinder pressure, and net rate of heat release also changes. On advancing the injection, the pressure in the cylinder reaches to higher value as compared to the retarded injection scheme. This is mainly due to the fact that, on advancing the injection, larger amount of fuel is injected (injection starting earlier and stopping later). Higher pressure is also found before TDC with advancement due to early start of combustion.

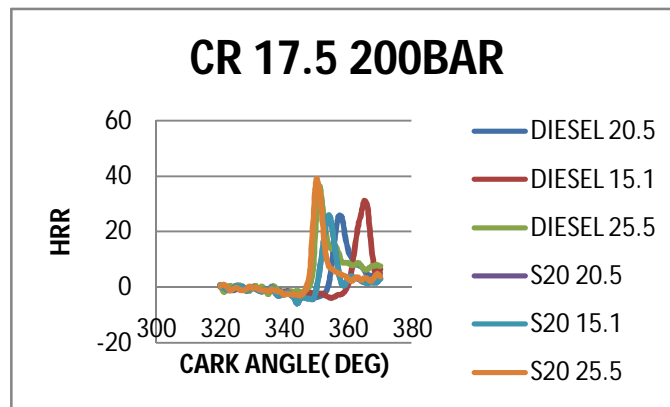


Fig 7 : Heat release rate V/s crank angle at different injection timing for diesel and S20

With advancement of injection timing, the peak rate of pressure rise increases but it shifts before TDC with shorter delay period. On retarding the injection, the rate of pressure rise decreases slightly with a shift away from TDC and the ignition delay also increases. Similar effects are seen on the rate of heat release. With retardation, larger amount of heat is released in mixing controlled combustion regime resulting in higher mean pressure in the cycle

VI. CONCLUSION

The fuel properties of biodiesel are comparable with that of diesel and lower blends with diesel are found suitable even for long term uses. Higher blends are still away from acceptance due to poor performance, mainly due to the reason that, the present age engines are the result of extensive research keeping petro diesel only as fuel in mind.

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Biodiesel being a fuel of different origin and quality, the engine design needs revision and different settings for optimum performance. As the combustion advances with biodiesel due to early entry, retarding the injection timing by 5⁰ is found to increase the thermal efficiency by 7% and reduce the specific fuel consumption by 6% when S20 is used as fuel.

Highest exhaust temperature and indicated power are obtained on 5⁰ retarded injection. By retarding the injection, the fuel delivery is also reduced resulting in slightly lower pressure rise with peak shifting towards outward stroke reducing the negative work.

REFERENCES

- [1] Dalai, A.K., N.N. Bakhshi, X. Lang, M.J. Reaney, P.B. Hertz and J. Munson, "Production of Diesel Fuel Lubricity Additives from Various Vegetable Oils", Annual Interim Report for Canodev Research Inc. April (2000).
- [2] Haas, M.J., Improving Economics of Biodiesel Production Through the Use of Low Value Lipids as Feedstocks: Vegetable Oil Soapstack, Fuel Processing Technology 86, 1087-1096 (2005).
- [3] Zhang, Y., Dube M. A., McLean D. D. and Kates M. "Biodiesel Production from Waste Cooking Oil: 2. Economic Assessment and Sensitivity Analysis", Bioresource Technology 90, (2003) 229-240.
- [4] W. Randall von. Technical handbook for marine biodiesel in recreational boats, Second edition 1999, viewed on 4 March 2007
- [5] J. Van Gerpen, B. Shanks, R. Pruszko, D. Clements and G. Knothe. Biodiesel Production Technology. Subcontractor report prepared under National Renewable Energy Laboratory, Colorado, 2004.
- [6] Vishwanath Kasturi, and M. C. Navindgi, "An Experimental Analysis of Performance, Combustion and Emission Characteristics of Simarouba Biodiesel and Its Blends on CI Engine", International Journal Of Modern Engineering Research (IJMER), Vol.4, pp.79-86, 2014.
- [7] Sharun Mendonca, and John Paul Vas, "Influence of Injection Timing on Performance and Emission Characteristics of Simarouba Biodiesel Engine", International Journal of Scientific and Research Publications, Vol.3, Issue 4, 2013.
- [8] Mishra S. R., Mohanty M. K., Das S. P., and Pattanaik A. K., "Production of Bio-diesel (Methyl Ester) from Simarouba Glauca Oil", Research Journal of Chemical Sciences, Vol.2(5), pp.66-71, 2012.
- [9] Shailesh Golabhanvi, Harish Astagi, and Omprakash Hebbal, "Performance, Emission and Combustion characteristics of a single cylinder diesel engine operating on simarouba biodiesel and diesel fuel", International Journal of Emerging Trends in Engineering and Development, Vol.3, pp.201-213, May 2014.
- [10] Vishwanath Kasturi, and M. C. Navindgi, "Experimental Investigation of Performance and Emission Characteristics of Simarouba Biodiesel and Its Blends on LHR Engine, International Journal Of Modern Engineering Research (IJMER), Vol.4, pp.63-69, 2014.
- [11] Dilip Sutraway, Y. U. Biradar, and V. V. Katti, "Effect of Fuel Injection Time on Performance of CI Engine Using (Simarouba) Biodiesel as Fuel, Journal of Mechanical Engineering Research and Technology, Vol.2, pp.556-572, 2014.
- [12] Malvya, s., Priyanka, N., Irfan-Ullah, M., Davande, S. and Joshi, P.K., "Distribution potential of simarouba glauca under climate change – strategizing rural livelihood application". Teri University, New Delhi
- [13] Vijay Kumar Garlapati, Ravi Kant, Annapurna Kumari, Paramita, lipase mediated transesterification of simarouba glauca oil: a new feedstock for biodiesel production", Garlapati et al. sustainable chemical processes 2013.
- [14] Amaramma, Arti.B and Shruthi.H. Experimental investigation on extraction of simarouba biodiesel and experimental investigation of its suitability as fuel for CI engine. June, 2014 vol 3 issue 6