International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 5, May - 2013

"Production Of Simarouba Bio-Diesel Using Mixed Base Catalyst, And Its Performance Study On Ci Engine".

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Abstract

Biodiesel is a fatty acid alkyl ester which is renewable, biodegradable and non toxic fuel which can be derived from any vegetable oil by transesterification process. In the present investigation, Simarouba oil based methyl ester (SOME) is produced by using a mixture of Sodium Hydroxide and Disodium Hydrogen ortho Phosphate, a mixed base catalyst by transesterification process. The properties of SOME thus obtained are comparable with ASTM biodiesel standards. The produced SOME is blended with diesel (Biodiesel-B10, B20, B30 and B100) were tested for their use as a substitute fuel for diesel engine. Tests have been conducted at different blends of biodiesel with standard diesel, at an engine speed of 1500 rpm, fixed compression ratio 17.5, fixed injection pressure of 200bar and varying brake power. The performance parameters elucidated includes brake thermal efficiency, brake specific fuel consumption, exhaust gas temperature, Carbon monoxide (CO), carbon dioxide (CO2), Hydrocarbon (HC) and oxides of nitrogen (NOx) emissions against varying Brake Power(BP).

Keywords – Biodiesel, Disodium hydrogen ortho Phosphate, Sodium Hydroxide, Simarouba oil methyl ester, Transesterification

"1. Introduction"

Diesel engine is a popular prime mover for transportation, agricultural machinery and industries. Import of petroleum products is a major drain on our foreign exchange sources and with growing demand in future years the situation is likely become even worse.The world is on the brink of energy crises. Efficient use of natural resources is one of the fundamental requirements for any country to become self sustainable with the fossil fuel depleting very fast, researchers have concentrated on developing new agro based alternative fuels, which will provide sustainable solution to the energy crises. There are more than 300 different species of trees in India, which produces oil [1]. India has the potential to be a leading world producer of bio diesel, as bio diesel can be harvested and sourced from non edible oils like Jatropha curcus, Pongamia pinnata, Neem, Mahua, caster, linseed etc.

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 [2]. It is mainly found in coastal hammocks throughout South Florida. 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 [6]; can grow well in marginal lands/wastelands with degraded soils and therefore considered as a major forest tree. However, in the present context the seeds are economically very important as they contain 60-75% oil [3]. Dry seeds of *S. glauca* contain 32-40% protein, with 59-62% unsaturated fatty acids which improves its nutritional profile. The Simarouba kernels shown in figure1 (Seeds of different size and shape is considered).

Figure1. Shows imarouba dried fruits, broken fruits, shells and kernels (top to bottom)

"2. Experimental methods"

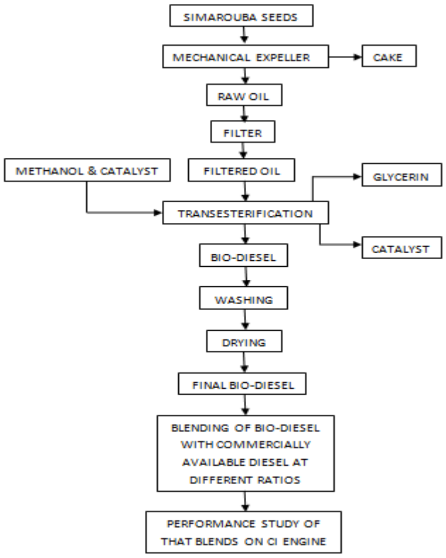
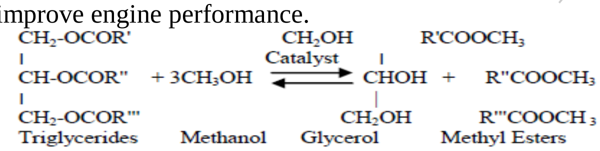


Figure2. Shows the methodology of Simarouba biodiesel production

2.1.Transesterification

Transesterification also called alcoholysis is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis, except that an alcohol is employed instead of water.This process is widely used to reduce the viscosity of triglycerides, thereby enhancing the physical properties of fuel and improve engine performance.



The apparatus is three neck glass reactor is shown in figure 3. equipped with a digital rpm controller with mechanical stirrer, a water condenser and funnel, and surrounded by a heating mantle controlled by a temperature controller device. A thermometer had been used to measure the reaction temperature. The NaOH, Na_2HPO_4[9,10] and CH_3OH solution were added to the closed reaction vessel[11]. The important parameter is stirring speeds and temperature which play a vital role in transestrification process[7].The mixture was heated to the required reaction temperature of 60-65^{0}C by the temperature controller for about 90mins with stirring speed of 600 rpm. After the reaction oil kept in a settling funnel for the process of separation. The separated layer of biodiesel, glycerin and catalyst is shown in figure 4.

Figure3. Transesterification setup

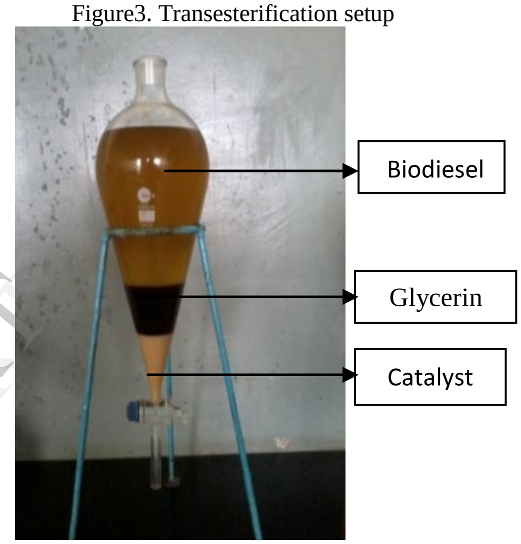


Figure4. Settling in separating funnel

"3.Fuel properties comparison"

Table1.The properties simarouba biodiesel is compared with diesel and standard biodiesel

Characterstics	SOME	ASTM Standard Biodiesel	Diesel
Kinematic Viscosity at 40^{0}C (mm^2/s)	4.7	1.9-6.0	2.54
Specific Gravity	0.865	0.87-0.90	0.82
Flash point (°C)	160	>110	54
Density (kg/m3)	865	870-900	820
Calorific value (kJ/kg)	37933	---	43500

"4.Experimental setup"

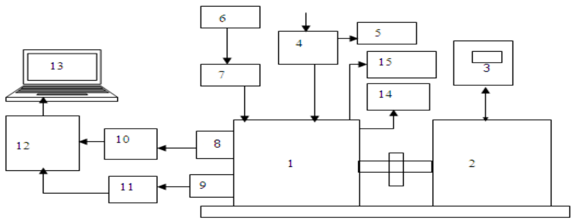


Figure5. Shows experimental setup

1.Diesel Engine	8.Pressure pickup
2.Electrical Dynamometer	9.TDC position sensor
3.Dynamometer controls	10.Charge amplifier
4.Air box	11.TDC amplifier circuit
5.U-tube manometer	12.A/D card
6.Fuel tank	13.Personal computer
7.Fuel measurement flask	14.Exhaust gas analyser
	15.AVL Smokemeter

Table2: The Experimental Results

Sl. No .	Parameters	Experimental Results at full load
1	Brake Power(BP)	4.23KW
2	Total Fuel Consumption(TFC)	1.14Kg/Hr
3	Brake Specific Fuel Consumption(BSFC)	0.269Kg/KWh
4	Brake Thermal Efficiency(BTE)	30.7%

"5.Results and discussion"

The experiments were conducted on a direct injection compression ignition engine for various brake power and various blends (Biodiesel-B10, B20, B30 and B100) of biodiesels[12,13,14]. Analysis of performance like brake specific fuel consumption, brake thermal efficiency, Exhaust gas temperature and emission characteristics like hydrocarbon, oxides of nitrogen, carbon monoxide and carbon dioxides are evaluated. The biodiesel used is as per ASTM standard, there is no modification in the engine. The experiment is carried out at constant compression ratio of 17.5:1 and constant injection pressure of 200bar by varying brake power.

5.1. Performance characteristics

a). Brake thermal efficiency (BTE)

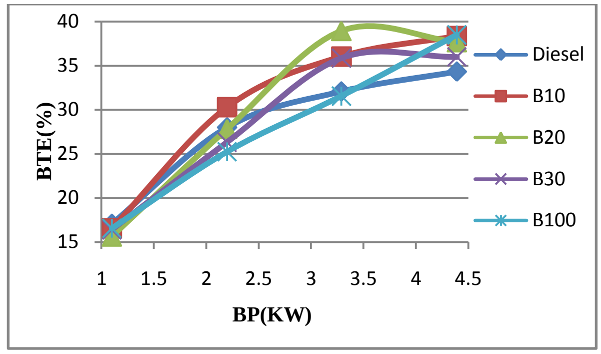


Figure6. Shows BP(Brake Power) VS BTE(Brake Thermal Efficiency) curve

Figure6 shows that the variation of brake thermal efficiency (BTE) with Brake power for different blends. Brake thermal efficiency is defined as the ratio between the brake power output and the energy of the fuel combustion.Graph shows as the Brake power increases the brake thermal efficiency increases to an extent and then decreases slightly at the end.The brake thermal efficiency reduces due to heat loss and increase in power developed with increase in brake power. The decrease in brake thermal efficiency for higher blends may be due to the combined effect of its lower heating value and increase in fuel consumption.The curve B30 is running nearer to the Diesel curve, which shows B30 blend can be a favourable to existing diesel engine.

b).Brake specific fuel consumption (BSFC):

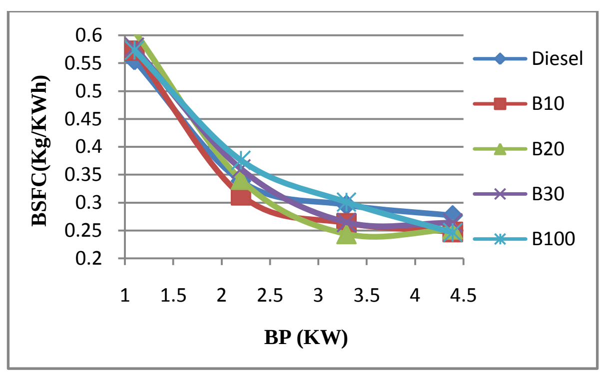


Figure7. Shows BP(brake power) VS BSFC(brake specific fuel consumption) curve

The variation of specific fuel consumption with respect to brake power is presented in Figure7 for different blends & diesel. In diesel engine due to less temperature initial combustion takes with maximum fuel consumption. At higher brake power the BSFC decreases. This may be due to fuel density, viscosity and heating value of the fuels. The curve B30 is almost tracing the path of diesel curve & this indicates blend B30 can be a favourable to existing diesel engine.

c). Exhaust Gas Temperature

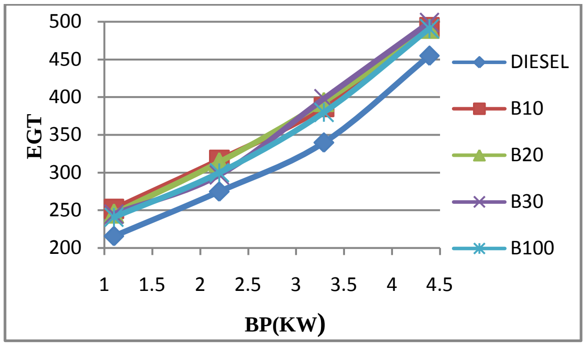


Figure8. Shows BP(brake power) VS EGT(exhaust gas temperature)

The variation of Exhaust gas temperature with respect to brake power is presented in Figure8 for different blends & diesel. The engine starts running with low temperature at low load. As the load increases the temperature inside the engine increases exponentially till it reaches full load. This rise of temperature is because of continuous flow of exhaust gas through outlet port.

5.2. Emission charecterstics

a). Hydrocarbon (HC)

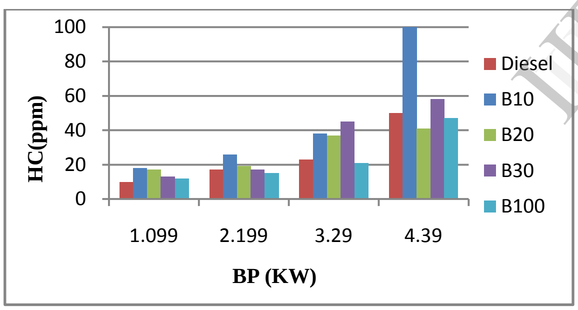


Figure9. Shows BP(brake power) VS HC(hydro carbon)

Figure9. shows the variation of hydro carbon emission with Brake power for different blends & diesel. Unburnt hydro carbons emission is the direct result of incomplete combustion. The HC emission for all the blends and diesel goes on increases. The hydrocarbon emissions of various blends are higher at higher loads except the blend B20 and B100. B100 has least HC emission in all cases and in blends, B30 shows the lower HC emission compared to neat diesel at full load. A reason for the reduction of HC emissions with biodiesel is the oxygen content in the biodiesel molecule, which leads to more complete and cleaner combustion.

b). Oxides of nitrogen (NOx)

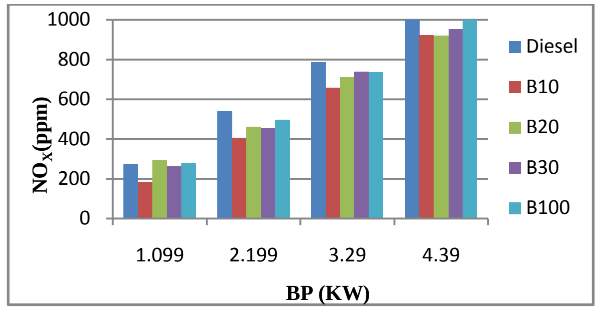


Figure10. Shows BP(brake power) VS NO_X(oxides of nitrogen)

Figure10: shows the variation of NOx emissions with brake power for different blends & diesel. The NOx emission for biodiesel and its blends is higher than that of standard diesel except B10 at lower loads. It is well known that the biodiesel contains a small amount of nitrogen. From the figure8, it is obvious that for 50% brake power, NOx emission from the SOME blend B10, B30 is lesser than that of diesel. But for full load the NOx emission from the blend B10, B20 is higher than that of diesel. The other blends closely follow standard diesel. The reason for higher NOx emission for blends is due to the higher peak temperature. The NOx emission for diesel and blend B10, B30 for 50% load is 541 ppm, 407 ppm and 463ppm respectively.

c).Carbon Dioxide (CO_2):

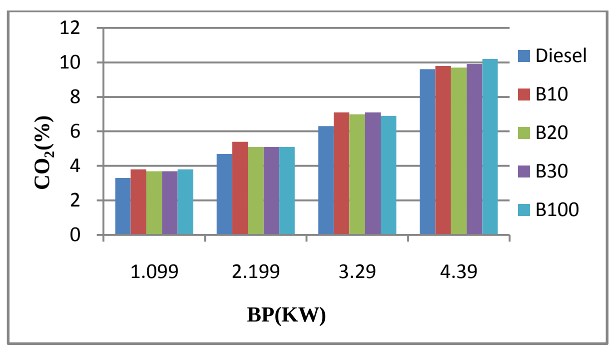


Figure11: Shows BP(brake power) VS CO_2(carbon dioxides)

Figure11: shows the variation of CO_2 emissions with brake power for different blends & diesel. The CO_2 emission for biodiesel and its blends is higher than that of standard diesel at all brake powers. As the load increases the supply of fuel increases which causes the emission of CO_2 at full brake power. In the figure B10,B20 and B30 blends showing similar values but blend B30 is preferred.

d). Carbon monoxide (CO):

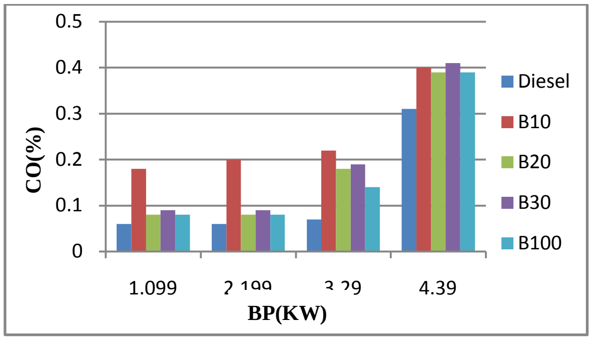


Figure12. Shows BP(brake power) VS CO (carbon monoxides)

Figure12: shows the variation of CO emissions with brake power for different blends & diesel. In the figure the emission of CO is less in the beginning but it is more at full brake power.

"6. Conclusion"

The present investigation evaluates production of SOME from Na_2HPO_4 and NaOH mixed catalyst and performance of SOME blends with diesel are compared with diesel in a single cylinder, 4-stroke water cooled diesel engine under varying brake power of engine operations. The following conclusions are drawn from this investigation.

Na_2HPO_4 and NaOH mixed catalyst will probably brought about as the good productivity as homogeneous catalyst (NaOH or KOH) and by taking advantage of the easy product recovery (mixed catalyst) i.e. while clear phase of glycerin is easily separated and in a pure form. Under optimum conditions, the conversion of Simarouba oil reached over 92 to 95%.

i).SOME satisfies the important fuel properties as per ASTM specification of Biodiesel.

ii).The existing diesel engine performs satisfactorily on biodiesel fuel without any significant engine modifications.

iii).Engine performance with biodiesel does not differ greatly from that of diesel fuel. The B30 shows good brake thermal efficiency in comparison with diesel. A little increase in fuel consumption is often encountered due to the lower calorific value of the biodiesel.

iv).Most of the major exhaust pollutants such as HC is reduced with the use of pure biodiesel and the blend as compared to diesel. But NO_X emissions increase when fuelled with diesel– biodiesel fuel blends as compared to conventional diesel fuel. This is one of the major drawbacks of biodiesel.

v).Among the blends, B30 gives better results as Brake thermal efficiency, brake specific fuel consumption, Exhaust gas temperature, hydrocarbons, oxides of nitrogen, Carbon monoxides and Carbon dioxides without any modification in the diesel engine..

vi).In view of the petroleum fuel shortage, B30 blend biodiesel can certainly be considered as a potential alternative fuel.

vii).The use of mixed catalyst yields more biodiesel **(920ml-950ml)** and the catalyst will be used 4 to 5 times by the addition of NaOH.

Viii).The cost of mixed catalyst is less as compared to the homogeneous catalyst like KOH, NaOH.

"7.Acknowledgement"

We thank Biofuels I&D center, SIT, Tumkur-572103, Karnataka, India and R&D Centre, Mechanical Department, SVCE College of Engineering, Sriperumbettur, Chennai, Tamil Nadu, India for providing necessary experimental setup to perform this research.

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