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Experimental Investigation of Rubber Seed Oil as Biodiesel on C.I. Engine

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Abstract— **The depleting fossil fuel resources, increases the price of fuel continuously. At one point of time the whole resources may come to end. Keeping this in view many researchers identified various alternative fuels and tested successfully. In the present investigation the performance and emission characteristics of single cylinder four stroke direct injection diesel engine using rubber seed oil(RSO) as an alternate fuel is evaluated. Here rubber seed oil is used in the form of blends at various proportions with diesel. High viscosity is one important difference between rubber seed oil and commercial diesel fuel. Bio-diesel is prepared from rubber seed oil using double Transesterification process. A single cylinder, four stroke, constant speed, water cooled, direct injection diesel engine is used for the experiment. The performance of the engine is measured using rope brake dynamometer and the emissions such as CO ,CO_2, HC & No_x is measured using exhaust gas analyzer. The experimental data for various parameters such as thermal efficiency, brake specific fuel consumptions (BSFC) are analyzed. Acceptable thermal efficiencies of the engine were obtained with blends containing upto B30 of rubber seed oil biodiesel blend** .

Keywords— *Alternative fuel, Biodiesel, Rubber seed oil, Engine Performance.*

I. Introduction

Biofuels is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modifications. Biodiesel is made through a chemical process called transesterification whereby the glycerin is separated from the fat or vegetable oil. The process leaves behind two products-methyl esters (the chemical name for biodiesel) and glycerin (a valuable byproduct usually sold to be used in soaps and other products. The transesterification is achieved with monohydric alcohols like methanol and ethanol in the presence of an alkali catalyst. Biofuels is a generic term and includes a large number of fuels. We are, however, concerned, at the present moment, with biofuels that will be used in the transport sector. So Biodiesel can be defined as a renewable liquid fuels coming from biological raw material and have been proved to be good substitutes for oil in the transportation sector. As such biofuels ethanol and biodiesel- are gaining worldwide acceptance as a solution to environmental problems, energy security, reducing imports, rural employment and improving agricultural economy. The production of biofuels utilizing presently under-utilized resources of land and hence providing nutrients to soil, checking soil erosion and thus preventing land degradation. The search for alternative fuels has been on for long. Bio diesels offer an attractive opportunity to conserve and economize use of conventional fuels like petrol and diesel. Bio fuels are being used the world over as admixtures with conventional fuels at levels that do not require modifications of internal combustion engines. The oil extracted from plants such as Rubber, Jatropha, Pongamia pinata, etc., can be processed into bio fuel. In fact, Jatropha is a very hardy plant that grows well in semi arid conditions and is not browsed by cattle or attacked by pests. The process involved in producing bio fuel from these plants can generate employment especially in the rural areas. Biodiesel and its blends with petroleum-based diesel fuel can be used in diesel engines without any significant modifications to the engines. The advantages of biodiesel are that it displaces petroleum thereby reducing global warming gas emissions, tail pipe particulate matter, hydrocarbons, carbon monoxide, and other air toxics. Biodiesel improves lubricity and reduces premature wearing of fuel pumps, and thus improves the efficiency and durability of the engine. Biodiesel is simple to use, nontoxic, and essentially free of sulfur and aromatics. One of the main advantages of biodiesel is biodegradable and nonflammable with very high flash points. **[1]**. Research on vegetable oil use in diesel engine is still progressing today. The results of exhaust emissions characteristics of ordinary Malaysian coconut oil blended with conventional diesel oil in a diesel engine. The results showed that the addition of 30% coconut oil with diesel oil produced higher brake power with a net reduction in exhaust emissions. The experiments were undertaken to test a diesel engine using oil composed of cottonseed oil and conventional diesel fuel **[2]**.

In this study, the performance parameters and thermal efficiencies of a single-cylinder, four-stroke diesel engine using diesel fuel and biodiesel, which is cottonseed oil methyl ester (CSOME), have been calculated. The calculations are done from theoretical data for petroleum diesel, Jatropha biodiesel and cottonseed oil methyl ester. *Experimental* **[3, 4]**. Acceptable thermal efficiencies of the engine were obtained with blends up to J50. The performance of *Jatropha* oil blends in a diesel engine is examined. The most significant conclusion from the study was that the J2.6 produced maximum values of brake power and brake thermal efficiency as well as minimum values of specific fuel consumption. It indicates that the successful use of *Jatropha* oil is a function of engine type, and percentage of *Jatropha* oil in the blends. Different vegetable oils such as soybean oil, castor oil, rapeseed oil, Jatropha curcas oil, cottonseed oil are considered as alternative fuels for diesel engines. The important advantages of vegetable oils as fuel are that they are renewable, can be produced locally, cheap and less pollutant for environment compared to diesel fuel. According to literature, use of vegetable oils as fuel in diesel engines causes several problems, namely poor fuel atomization and low volatility originated from their high viscosity, high molecular weight and density. After the use of vegetable oils for a long period of time, these problems may cause important engine failures. To improve fuel properties and decrease viscosity and density of oils, various methods such as heating the vegetable oils, mixing with diesel fuel, emulsion with alcohol and transesterification have been employed **[5, 6]**.

Jatropha oil was identified as a leading candidate for the commercialization. Vegetable oils are considered to be suitable for Thailand due to its agricultural economy, and can help alleviate the problem of under-priced agricultural products. Thailand is blessed with many feedstocks, suitable for vegetable oil production such as palm, *Jatropha*, coconut and sunflower. These crops can be used to produce vegetable oil for usage in the agricultural sector; to decrease the dependence on imported oil and to help stabilize the price of agricultural products. The use of non-edible vegetable oils compared to edible oils is very significant because of the tremendous demand for edible oils as food, making them too expensive to be used as fuel at present.

The scientific name of *Jatropha* is *Jatrophs curcas* L. and *Jatropha* oil is one such kind of non-edible vegetable oil. Not only does *Jatropha* have a yield of well over 200 gallons of oil per acre per year, eleven times that com and it can potentially be used for food crops in subsequent years. *Jatropha* is a perennial which can grow in arid conditions on any kind of ground, and does not suffer in droughts or require irrigation. Therefore, unlike the common biofuel crops of today (corn and sugar); they are very easy to cultivate, even on poor land. *Jatropha* is fast growing, begins yielding oil in the second year and continues for forty to fifty years. Optimal yields are obtained from the sixth year. By investigating *Jatropha* oil and its methyl ester to find out their suitability for use as petro-diesel. Different properties of *Jatropha* oil were experimentally determined and compared with theoretical equations developed in the study. The study suggested that *Jatropha* oil can be used as a source of triglycerides in manufacture of biodiesel cost-effectively. *Jatropha* oil in a diesel engine is investigated **[7, 8 and 9]**. Many experiments have clearly revealed that the widely applied and convenient method for reduction of viscosity and density of vegetable oils is transesterification. The fuels produced via transesterification of the oils are called biodiesel. An important property of biodiesel is its oxygen content of about 10%, which is usually not contained in diesel fuel. In spite of transesterification treatment, viscosity and density of biodiesel is still higher than that of diesel fuel. It is well known that viscosity of fuels affects some processes such as atomization, vaporization and fuel–air mixing in the engine. The engine performance and emissions of diesel engines fuelled with biodiesels have been examined by many investigators. The biodiesels used in the experiments performed by these investigators were produced from different vegetable oils such as cottonseed, sunflower, rapeseed, soybean, karanja, rubber seed, etc **[10, 11]**. A heat exchanger, preheated *Jatropha* oil has the potential to be a substitute fuel for diesel engines. Optimal fuel inlet temperature was found to be 80°C considering the brake thermal efficiency, brake specific energy consumption and gaseous emissions. A comparable engine performance and emissions are reported by using preheated peanut, sunflower and canola oils in two DI diesel engines. Seven non-edible vegetable oils including *Jatropha* oil as an alternative fuel for diesel engine**[12, 13]**. The experimental results showed that a mixing ratio of 30% cottonseed oil and 70% diesel was optimal in ensuring relatively high thermal efficiency of the engine. The use of hazelnut oil as an alternative fuel in pre-chamber diesel engines, and compared it with diesel **[14]**. The results showed that the hazelnut oil may be employed in most diesel operating conditions in terms of the performance and emission parameters without any modification or preheating of the fuels. A series of engine tests, with and without preheating have been conducted using each of the above fuel blends for comparative performance evaluation. The results of the experiment in each case were compared with baseline data of diesel fuel. Significant improvements have been observed in the performance parameters of the engine as well as exhaust emissions, when lower blends of karanja oil were used with preheating and also without preheating. Karanja oil blends with diesel (up to K50) without preheating as well as with preheating, can replace diesel for operating the CI engines, giving lower emissions and improved engine performance. It can also be concluded that preheating of the fuel has some positive effects on engine performance and emissions when operating with vegetable oil.

II Bio-fuels have the following advantageous properties:

- Bio fuel yielding trees having high oil-bearing capacity.
- Renewable and alternative energy sources.
- Easy to develop and use.
- Low-cost and not a-very-high-tech route, therefore, can be readily implemented, environmentally safer and compatible.
- Biodiesel provides more lubrication than petroleum diesel.
- Biodegradable, non-toxic and free of sulphur and aromatic compounds, therefore, no SO_x emissions.
- Bio-fuel is an ideal synergistic partner for oxidation catalytic converter and reduces CO_2 emissions by 78 % when compared to conventional diesel fuel.
- Bio-diesel is an oxygenated fuel with O_2 content of about 10 % and therefore gives better emission characteristics in term of CO, Hydrocarbons, and Particulate matter.
- Also, Bio-diesel has a higher Cetane number, ensuring low noise and smooth running, during engine combustion.
- In addition, the by-product resulting after extracting bio fuel is an excellent source of nitrogen rich organic fertilizer.

III Properties of NME (Rubber Seed Oil)

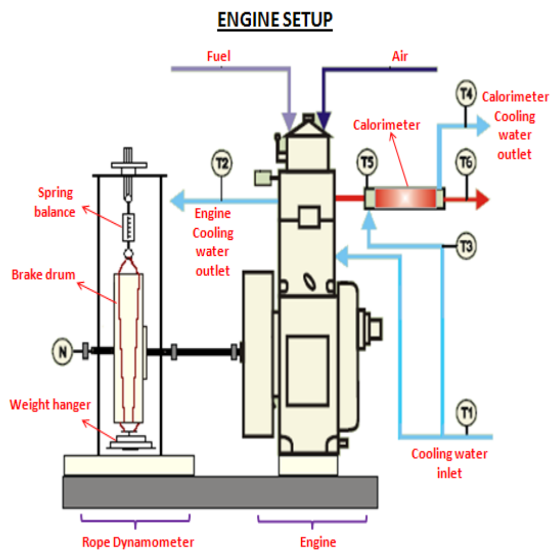
Test property	Rubber Seed Oil
Flash point (^{0}c)	175
Fire point (^{0}c)	181
Density (Kg/m^3)	879.76
Kinematic viscosity at 34 ^{0}c (CSt)	74.42
Calorific value (KJ/Kg)	31432

IV Calorific values for different rubber seed oil blend in diesel:

DIESEL_RUBBER SEED OIL BLENDS	CALORIFIC VALUE(kJ/kg)
PURE DIESEL	42688
90%D+10%N(B10)	40020.57
85%D+15%N (B15)	39676.49
80%D+20%N (B20)	38150.56
75%D+25%N (B25)	37850.42
70%D+30%N(B30)	37610
NME	31432

V. Experimental setup

Line diagram of engine setup



VI. Engine specifications:

Make	- Kirloskar model AV1
No. of Strokes per cycle	-4
No. of Cylinders	-1
Combustion Chamber position	-vertical
Cooling technique	-water cooled
Starting condition	- Cold start
Ignition technique	-Compression Ignition
Bore (D)	- 80mm
Stroke (L)	-110mm
Rated Speed	- 1500 rpm
Rated Power	- 5 hp (3.72 kW)
Compression ratio	- 16.5: 1
Fuel	- H.S. Diesel Oil

VII .Load Test on diesel engine with diesel & Rubber Seed Oil blends alternatively at constant speed.

- Brake thermal efficiency of the engine
- Brake power of the engine
- Indicated thermal efficiency of the engine
- Specific fuel consumption of the engine
- Volumetric efficiency of the engine

VIII. Performance Curves

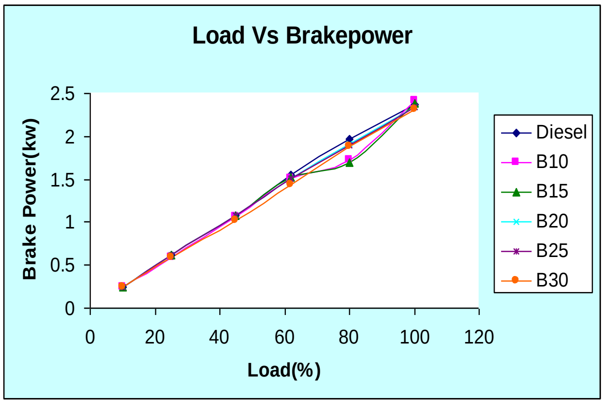


Fig:1

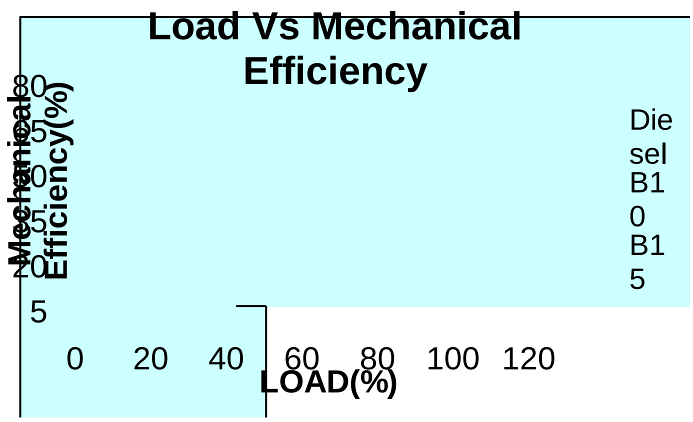


Fig:2

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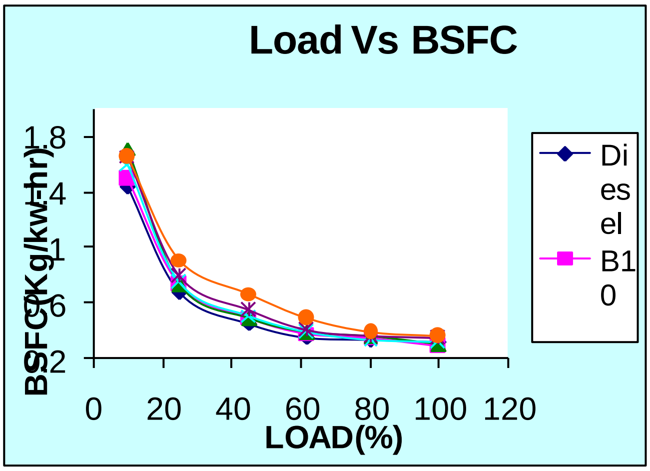

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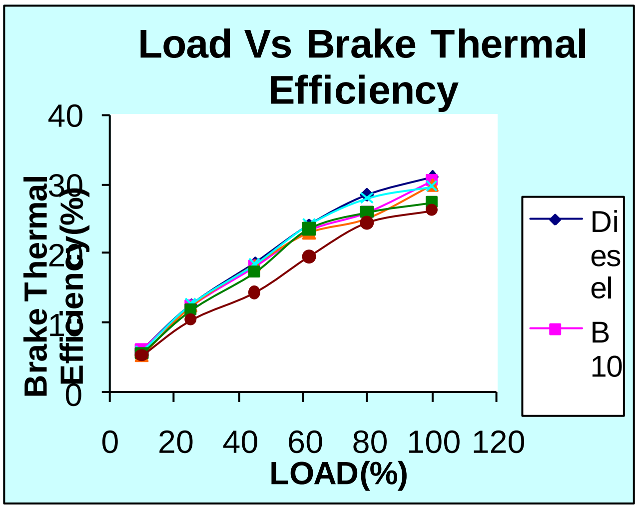

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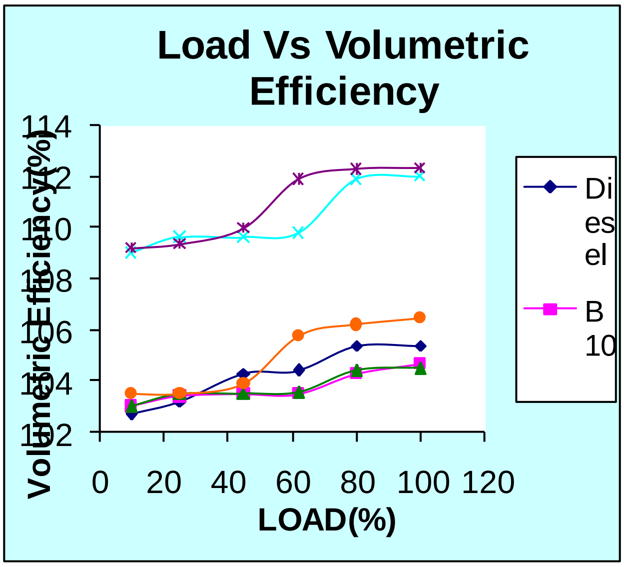

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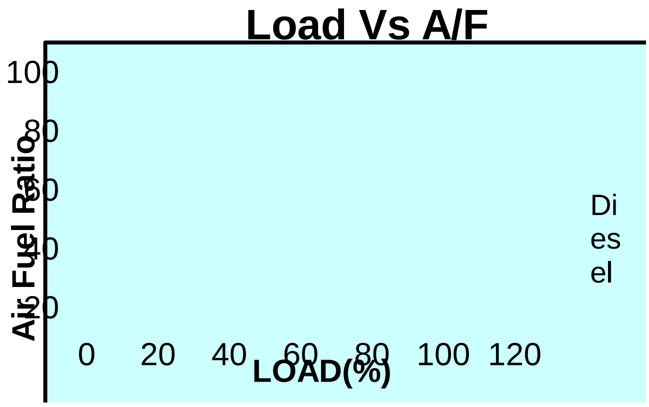
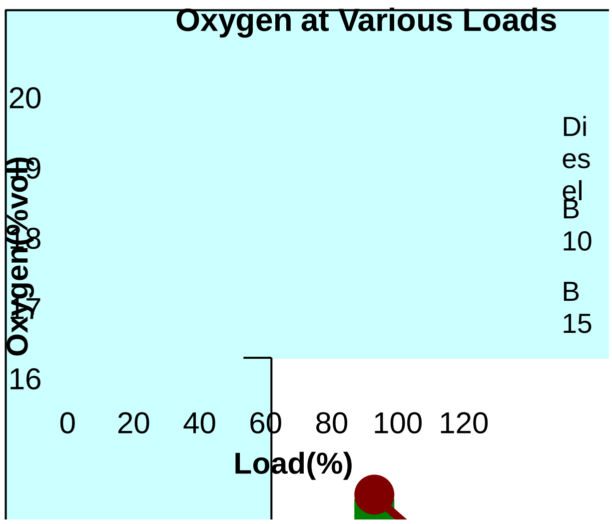


Fig:6

IX.Emission Curves For Pure Diesel And Different Blend



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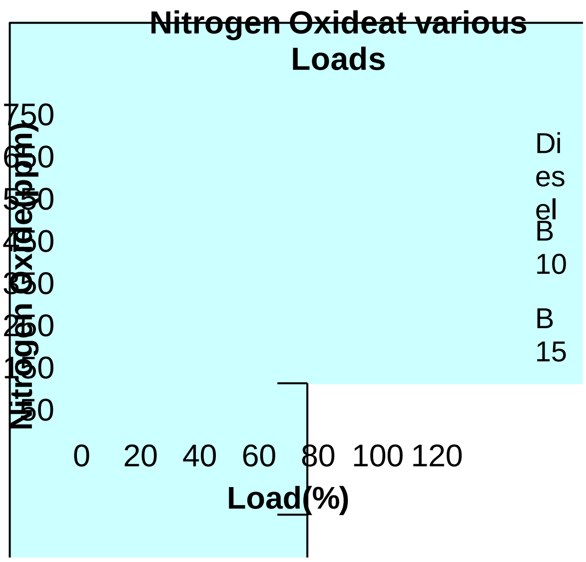

Fig:8

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Volume No.3 Issue No: Special 1, pp: 58-64 22nd March 2014

X. Results and discussions:

The experimental investigation was carried out for different blends of Rubber Seed Oils (biodiesel) and the performance was evaluated and compared with diesel.

1. In Fig.1, the Kinematics Viscosity (at room temperature of 35°C) of different blends of methyl ester B10, B15, B20, B25 and B30 are higher than the viscosity of diesel. But up to B20 the viscosity of biodiesel is very close to the viscosity of diesel. So that the biodiesel of B10, B15 and B20 blends can be used with out any heating arrangement.

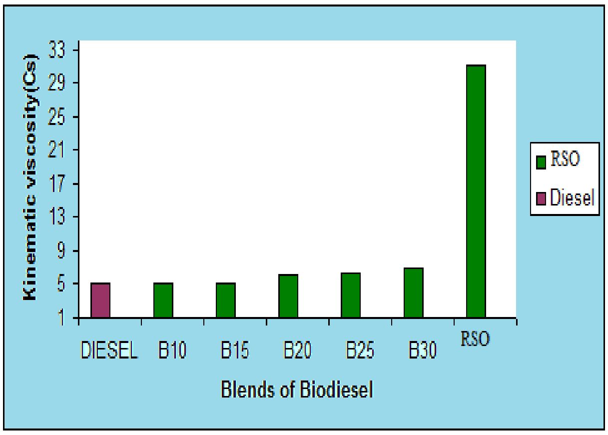


Fig.1: Kinematic Viscosity Vs Blends

2. The density of different blends of methyl ester is increased with increase in blend percentage as shown inFig.2. The blends of B10, B15 and B20 of Rubber Seed Oils are closer to the viscosity of diesel, because of which Rubber Seed Oils are an alternative fuel for diesel. The high density of methyl esters (B25, B30 etc.) can be reduced by heating of fuel.

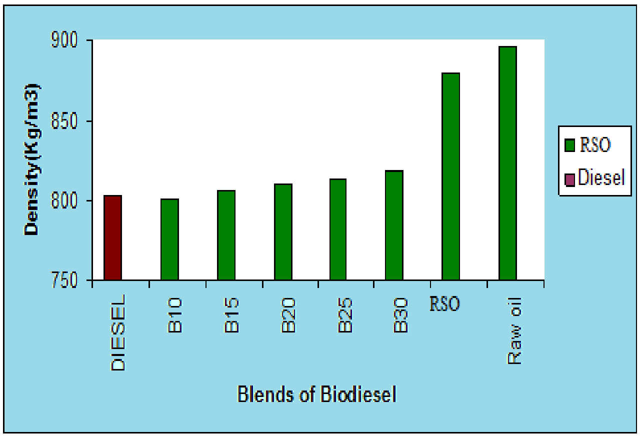


Fig.2: Different Blends of Biodiesel Vs Density

3. The flash points of different blends of methyl ester are increased with increase in methyl ester percentage as shown in Fig.3. It is also observed that the flash points of raw and esterifies oil is more compared to diesel. Thus, it can be used as a fuel without any fire accidents

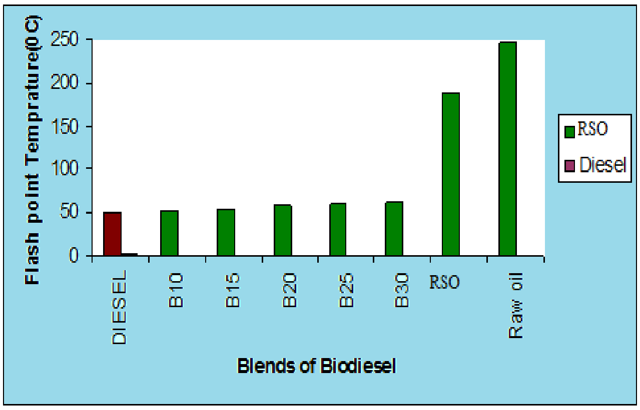
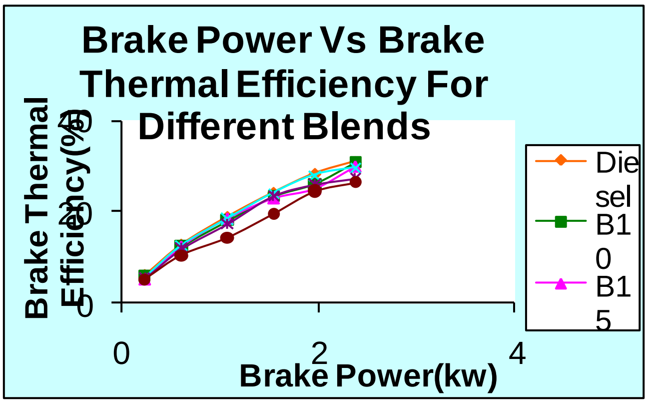


Fig.3: Blends of Biodiesel Vs Flash Point Temperatures

4. In Fig.4 to5, a slight drop in Brake Thermal efficiency was found with methyl esters (biodiesel) when compared with diesel. This drop in thermal efficiency must be attributed to the poor combustion characteristics of methyl esters due to high viscosity. It was observed that the brake thermal efficiency of B10, B15, B20 and B25 are very close to brake thermal efficiency of Diesel. B20 methyl ester had equal brake thermal efficiency with diesel. So B20 can be suggested as best blend to use in dieselengine.



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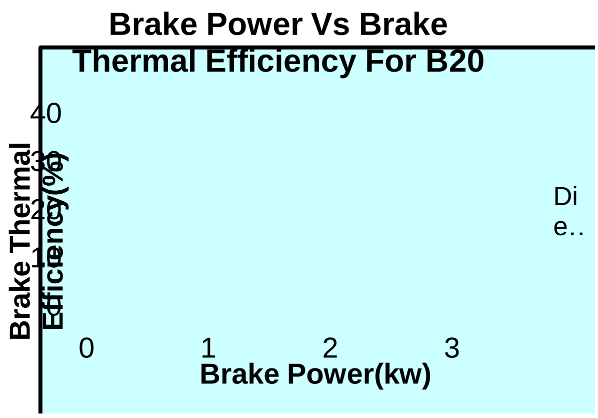

Fig: 5

5. Carbon monoxide and Carbon Dioxide was measured by Emission test for various blends of biodiesel and diesel. Biodiesel gives less Carbon monoxide and Carbon Dioxide than compared to petroleum diesel. When percentage of blend of biodiesel increases, Carbon monoxide and Carbon dioxide decreases, because air fuel ratio increases.

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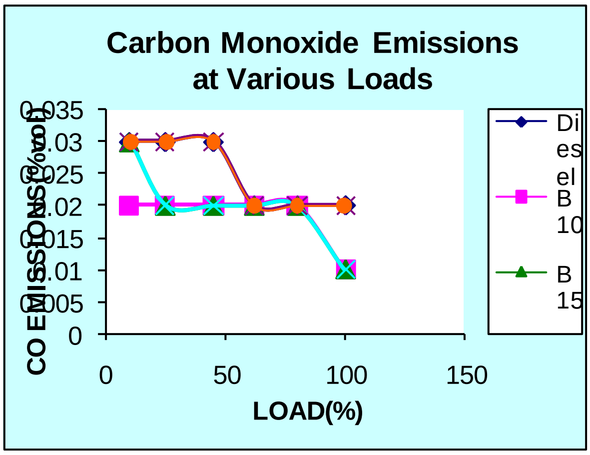

Fig: 6

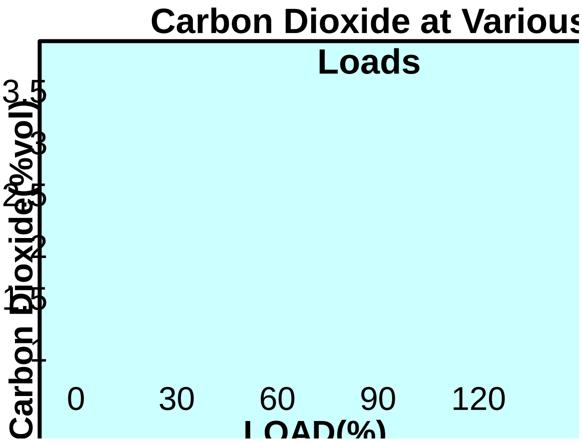

Fig: 7

6. A hydrocarbon was measured by Emission test for various blends of biodiesel and diesel. Biodiesel gives fewer Hydrocarbons than compared to petroleum diesel. When percentage of blend of biodiesel increases Hydrocarbons decreases, because oxygen content increases.

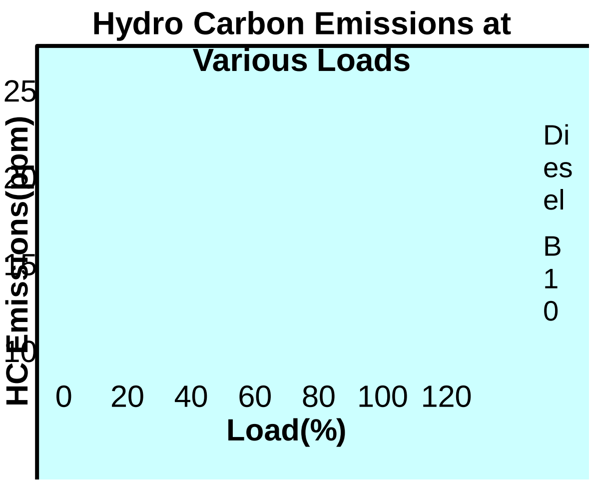

Fig: 7.

7. Knocking or Detonation decreases with the input of percent of Rubber seed oil Increases.

XI Conclusions:

Following are the conclusions based on experimental results obtained while operating single cylinder diesel engine fuelled with biodiesel from
Rubber Seed oils and their diesel blends.

- Rubber Seed based methyl esters (biodiesel) can be directly used in diesel engines without any engine modifications.
- Brake thermal efficiency of B10, B15, B20, and B25 blends are closer to Diesel, but still inferior to diesel.
- Properties of different blends of biodiesel are very close to the diesel and B20 is giving good results.
- It is not advisable to use B100 in CI engines unless properties are comparable with diesel fuel.
- Smoke, HC, CO emissions at different loads were found to be higher for diesel, compared to B10, B15, B20, B25 and B30 blends.
- Rubber Seed oil also works as a lubricant in the engine cylinder, so rate of wear of the engine cylinder and bore decreases.

Good mixture formation and lower smoke emission key factors for good CI engine performance. These factors are highly influenced by viscosity, density, and volatility of the fuel. For bio-diesels, these factors mainly decided by the effectiveness of transesterification process. With properties close to diesel fuel, bio-diesel from Rubber Seed oil can provide a useful substitute for diesel thereby promoting our economy.

XII. Recommendations

1. Using Diesel-Rubber Seed Oil blends, B20 Rubber seed oil blending (by volume) is recommended for diesel engine operation for better performance and low detonation.
2. Biodiesel is friendly to environment, so there is a possibility to reduce green house effect.
3. To reduce the viscosity of Rubber seed oil of other blends (B25, B30, etc.)As maximum as possible pre heaters is adapted for efficient running of engine

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