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Research Article

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Combustion characteristics of di-ethyl ether mixed *Thevetia peruviana* seed oil

[a]S. Varun Raj and [b]A. Muthu Manokar

[a]Mechanical Department, Vel Tech, Chennai - 600 062, India
[b]Mechanical Department, Dhaanish Ahmed College of Engineering, Chennai - 601301, India

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ABSTRACT

In the present of high energy consumption in every sphere of life, renewable energy sources are emerging as alternative to conventional fuels for energy security, mitigating green house gas emission and climate change. There has been a world wide interest in searching for alternatives to petroleum derived fuels due to their depletion as well as due to the concern for the environment. Vegetable oils have capability to solve this problem be cause they are renewable and lead to reduction in environmental pollution. But high smoke emission and lower thermal efficiency are the main problems associated with the use of neat vegetable oils in diesel engines. In the present work, performance, combustion and emission characteristics of CI engine fuelled with 5% by vol. Diethyl Ether (DEE) mixed with Thevetia Peruvina Seed Oil (TPSO). Various performance, combustion and emission characteristics such as thermal efficiency, and brake specific fuel consumption, volumetric efficiency are measured and results are revealed that 5% DEE mixed with biodiesel gives improved performance, combustion and emission characteristics.

Keywords: renewable energy, *Thevetia peruviana* Seed Oil, thermal efficiency

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INTRODUCTION

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs requiring huge investments to meet them.

Historically, any change in the prime energy source of a society has resulted in a revolution in the life style. Thus domestication of animals and resulting easy availability of draft animal power played a key role in transition from hunter-gatherer society, where human muscle power was the only source of energy to the agricultural society. Before the industrial revolution, which began around 200 years ago, people were essentially dependent on manual and animal labour. Energy requirements were met through food intake. Life was simple and unsophisticated, and the environment was relatively clean and pollution free. Then in 1785, the invention of steam engine by James Watt of Scotland brought industrial revolution. It was the beginning of the mechanical age or the age of machines. The advent of internal combustion engine in the late nineteenth century gave further momentum to the tread. Gradually industrial revolution spread to the whole world and the need for huge quantity of energy realized.

Discovery of large stocks of coal and steam engine heralded the industrial revolution with its mechanized production in eighteenth century. Slowly steam boilers and engines replaced animal draft power, wind mills and water wheels. Thus were sown the seeds of phenomenal increase in the carbon dioxide content of air, and in the economies of nations. The second industrial revolution of nineteenth century is usually associated with numerous discoveries resulting in technological advances, the two most important of these being the invention of electricity and modern usage of petroleum oil products in internal combustion engines.

1.1 INDIAN SCENARIO OF OIL CONSUMPTION

India's demand for petroleum products is likely to rise from 97.7 million tonnes in 2001-02 to around 139.95 million tonnes in 2006-07, according to projections of the Tenth Five-Year Plan. The plan document puts compound annual growth rate (CAGR) at 3.6 % during the plan period. Domestic crude oil production is likely to rise marginally from 32.03 million tonnes in 2001-02 to 33.97 million tonnes by the end of the 10^{th} plan period (2006-07). India’s self sufficiency in oil has consistently declined from 60% in the 50s to 30% currently. Same is expected to go down to 8% by 2020. As shown in the figure 1.8, around 92% of India’s total oil demand by 2020 has to be met by imports.

Rising petroleum prices, increasing threat to the environment from exhaust emissions and global warming have generated an intense international interest in developing alternative non-petroleum fuels for engines. In recent years, research has been directed to explore plant-based fuels and plant oils and fats as fuels. Biodiesel is described as a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. It is oxygenated, essentially sulfur-free and biodegradable.

2. LITERATURE SERVEY

The concept of biofuel dates back to 1885 when Dr. Rudolf Diesel built the first diesel compression ignition engine with full intention of running it on vegetative source (Shay 1993). In 1912, he observed, the use of vegetable oils for engine fuels may seem insignificant today. But such oils may in the course of time become as important as petroleum and the coal tar products of present time.” However, due to cheap petroleum products, and probably due to economic might of the cartels, investigations of such non-conventional fuels never took off to offer any viable ideas.

In the recent past the search for new source of biodiesel and their effective utilization had been a hot topic among the researchers in India and abroad. In the few years, many researchers have taken intensified work in the field of utilization of biodiesel in CI engine and some of the results are described below.

Several studies have shown significant reductions in smoke and particulate matter (PM) emissions from diesel engines when oxygenates are blended with conventional diesel fuels. There is an interest in oxygenates, and fuel properties such as hydrogen to carbon ratio, aromatic content, and number of carbon-carbon bonds were used as correlating parameters for smoke formation in hydrocarbon flames. All the studies showed a significant reduction in smoke and PM emissions when either pure oxygenates or oxygenate/diesel blends were burned in diesel engines. As a compression ignition fuel, DEE has several favorable properties, including an outstanding cetane number and a reasonable energy density for onboard storage, and in addition, it is renewable. Hence, it can be used as an additive to reduce the ignition delay and improve mixture formation with vegetable oils. Ether-bound oxygen seemed to be more effective in smoke reduction than alcohol- bound oxygen. This research on diesel engines fueled with DEE mixed biodiesel have revealed that the fuel economy and performance were better than those of diesel engines without this oxygenate.

Barnwal B K et.al,(2005) explained the prospects of biodiesel production from vegetable oils in India and reported that biodiesel production and utilization, resource available, process develop/being develop, performance of existing engine, environmental consideration, the economic aspect and advantages in and barriers to the use of biodiesel were elaborated.

Bora D K, et.al,(2004) conducted a performance evaluation and emission characteristics of a diesel engine using mahua oil methyl ester and reported that methyl ester of mahua oil oilcan be used in the existing diesel engine without substantial hardware modification.

Kumar N et.al.,(2004) reported that fuelling agriculture engine with derivative of palm oil had comparable performance and less emission and suggest to use 10-20% of biodiesel developed from palm oil in diesel engine without any difficulty.

Kumar R et.al., (2004) biodiesel from Jatropha curcas and Pongamia pinnata was used as fuel in direct injection diesel engine and reported that 20% blend gives comparable performance and less emission.

Leenus Jesu et.al., (2005) conducted Performance and emission characteristics of a CI engine fueled with esterified cottonseed oil and reported that engine exhibited a very good performance without any problems of combustion and suggested to use ethyl ester of cotton seed oil as a alternate fuel for diesel engine.

Ramadhas A S et.al.,(2004) conducted a review on use of vegetable oils as IC engine fuels and reported that production and characterization of vegetable oil as well as the experimental work carried out in various countries in this field. Also, the scope and challenges being faced in this area of research are clearly described.

EXPERIMENTAL SECTION

In the present work, an attempt has been made to extract oil from "MANJARALI SEED (*Thevetia Peruviana*)". Di-Ethyl ether mixed *Thevetia peruviana* seed oil (TPSO) was prepared using trans-esterification technique. Properties of the biodiesel were found as per the ASTM standard. Performance, combustion and emission characteristics of CI engine fuelled with 5% by vol. Diethyl Ether (DEE) mixed with *Thevetia Peruvina* Seed Oil (TPSO). Various performance, combustion and emission characteristics such as thermal efficiency, and brake specific fuel consumption were measured. Results are revealed that 5% DEE mixed with biodiesel gives improved performance, combustion and emission characteristics.

Thevetia peruviana **(Manjarali) Seed Oil Introduction**

Yellow oleanter [*Thevetia peruviana* (Pers.) Merrill], called Manjarali in Tamil Nadu, is a small ever green tree (3-4m high) cultivated as an ornamental plant in tropical and subtropical region of the world, including India. Fruit contains 2-4 flat gray seeds, which yield above half liter of oil from 1 kg of dry kernel. This oil is taken up to test the fuel properties as per ASTM codes. In these plant can be cultivated in waste lands. It requires minimum water when its growing stage. It start flowering after one and a half year. After that it blooms thrice every year. In hectare 3000 saplings can be planted and out of which 52.5 tones of seeds (3500 kg of kernel) can be collected. Hence about 1750 liters of oil can be collected from a hectare of waste land.

Fig.1 ***Thevetia peruviana*** **Flower**

Fig. 2 ***Thevetia peruviana*** **plant with Fruit**

Sodium hydroxide (4g) is added to methanol (200 ml) and stirred until properly dissolved. The solution is added to TPSO (1000 ml) and stirred at a constant rate at 60°C for 1 h. After the reaction is over, solution is allowed to settle for 4-5 h in a separating flask. Coarse biodiesel, separated from glycerin, is heated above 120°C and maintained for

10-15 min for removing untreated methanol. Certain impurities like NaOH were cleaned two or three times by washing with 50 ml of petroleum ether and 100 ml of water for 1000 ml of coarse biodiesel. This cleaned biodiesel was taken up for the study in various blends (B10,B20, B40, B60, B80 and B100) with diesel.

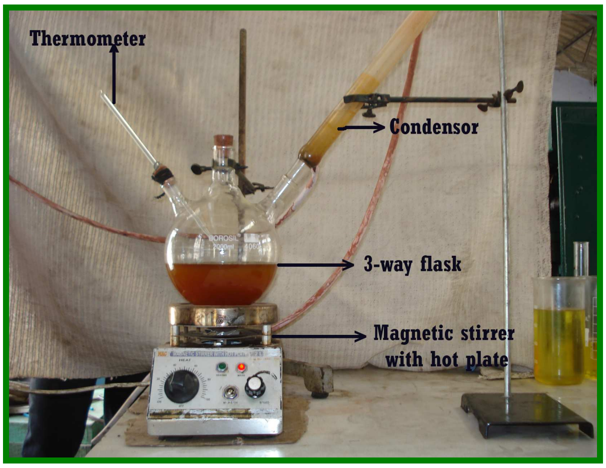

Fig.3 Transesterification setup

PROCEDURE

Engine Specification

A two separate fuel tanks with a fuel switching system are used, one for diesel (D100) and the other for biodiesel (B100). Fuel consumption is measured using optical sensor. A differential pressure transducer is used to measure airflow rate. Engine is coupled with an eddy current dynamometer to control engine torque through computer. Engine speed and load are controlled by varying excitation current to eddy current dynamometer using dynamometer controller.

A piezoelectric pressure transducer is installed in engine cylinder head to measure combustion pressure. Signals from pressure transducer are fed to charge amplifier. A high precision crank angle encoder is used to give signals for top dead centre and crank angle. The signals from charge amplifier and crank angle encoder are supplied to data acquisition system.

An AVL exhaust gas analyzer and AVL smoke meter are used to measure emission parameters and smoke intensity respectively. Thermocouples (chrommel alumel) are used to measure exhaust temperature, coolant temperature, and inlet air temperature.

Experimental Procedure (Base Line)

- The flow of air, the level of lubricating oil and the fuel level are checked before starting the engine
- First of all base line reading is taken with diesel
- The engine is cranked by keeping the decompression lever and the fuel cut off lever of the fuel pump in the ON position
- When the engine starts, the decompression lever is disengaged and the speed of the engine is increased to 1500 rpm and maintained.
- The engine is allowed to run for 15 minutes to reach the steady state conditions.

Two separate fuel tanks with a fuel switching system are used, one for diesel (D100) and the other for biodiesel and it's blends. Fuel consumption was measured using optical sensor. A differential pressure manometer was used to measure airflow rate. Engine was coupled with an eddy current dynamometer to control engine torque. Engine speed and load were controlled by varying excitation current to eddy current dynamometer using dynamometer controller. An AVL-444 exhaust gas analyzer and AVL-437 smoke meter were used to measure emission parameters and smoke intensity respectively. Load was changed in five levels from no load to maximum load conditions. The engine was operated at 1500 rpm for all tests. Special care was taken to maintain steady condition for every reading. Performance and emission parameters were measured such as

- Brake thermal efficiency (BTE)
- Brake specific fuel consumption (BSFC)
- Volumetric efficiency

All the above parameters were compared with that of diesel operation and analyzed.

RESULTS AND DISCUSSION

Performance and combustion characteristics were investigated on a CI engine fuelled with blends of di-ethyl ether TPSO and diesel. An effort has been put to study the effect of combustion characteristics of the CI engine fuelled with 20% TPSO blended with diesel.

Performance and combustion characteristics of compression ignition engine using bio diesel as fuel at different blending rates analysed. To control the emission rates such as NOx and smoke bio diesel is oxygenated using Di-Ethyl Ether or peroxide.

The CI engine is tested using the following bio diesel blends and diesel

- D100 – Pure diesel (Petro diesel)
- B20 – 20% bio diesel
- B40 - 40% bio diesel
- B60 - 60% bio diesel
- B80 - 80% bio diesel
- B100 --- 100% bio diesel

The following observations were taken while testing the CI Engine using Bio diesel with different blending rates.

Brake Thermal Efficiency

Figure 4 shows the variation of the brake thermal efficiency of the base diesel, TPSO, METPSO and METPSO with 5%DEE. The brake thermal efficiency obtained with TPSO is lower compared to that of diesel at full load. The brake thermal efficiency obtained with diesel is 37.5%, and with TPSO, it is 28.2%. The reduction in efficiency in the case of TPSO is due to poor mixture formation as a result of low volatility and higher viscosity, which leads to poor combustion in the case of TPSO. It is observed that there is an improvement in the brake thermal efficiency with DEE. The DEE mixing with TPSO brake thermal efficiency at full load is 34.9 %.

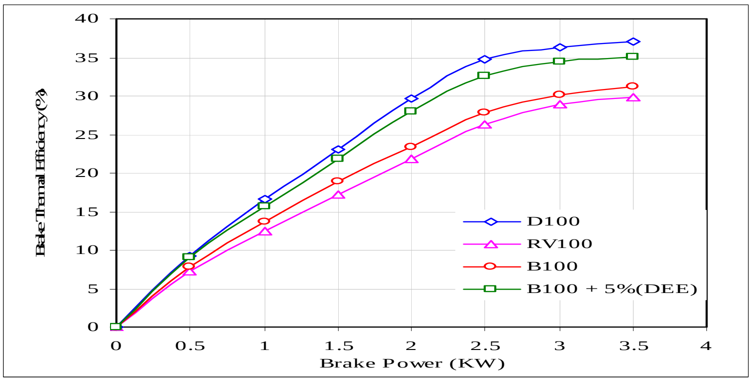

Fig.4 Variation of Brake Thermal Efficiency with Brake Power

When DEE is mixed with B100, it evaporates quickly, mixes easily with air and forms a homogeneous mixture, and results in combustion, creating a hotter environment to assist the combustion of TPSO, which leads to higher thermal efficiency.

Brake specific fuel consumption

The variation of the bsfc with the brake power is shown in Figure 5. The bsfc of TPSO is higher than those of TPSO with DEE and diesel. The bsfc at full load in TPSO is 1.25 Kg/ (kW h), compared to that of TPSO with DEE of 1.01 Kg/ (kW h) and that of diesel of 0.91 Kg/ (kW h).

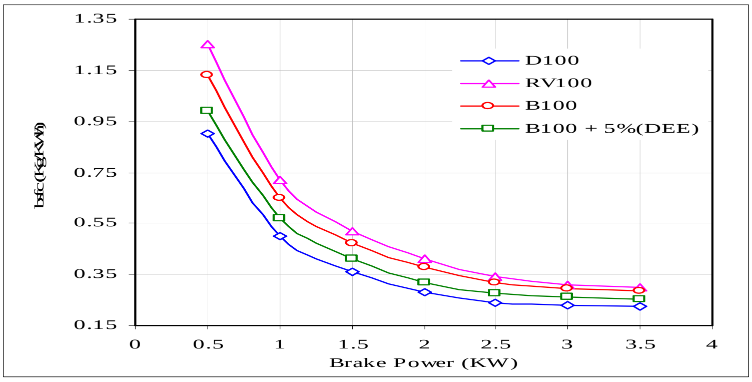

Fig.5 Brake Power Vs bsfc

The increase in the bsfc of an engine fueled by TPSO is due to low volatility and high density and viscosity, which affect the mixture formation, leading to slow combustion. The injection of a small quantity of DEE increases the flame speed of TPSO, which enhances combustion. This results in a high-energy output for the same quantity of TPSO. Due to this, the BSEC is reduced in DEE compared with neat TPSO.

Volumetric efficiency

Figure 6 shows the variation of the volumetric efficiency with the brake power. It is also observed that volumetric efficiency of all fuels decreased with increase of load.

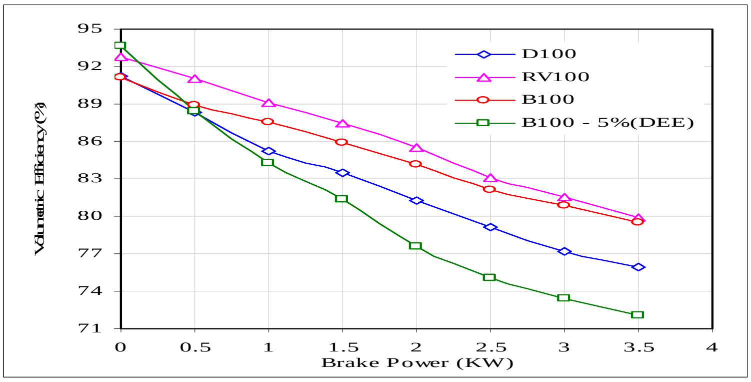

Fig.6 Brake Power Vs Volumetric efficiency

It is observed that volumetric efficiency of TPSO is higher than those of TPSO with 5 % DEE and diesel. The volumetric efficiency at full load in TPSO is 80% compared to that of TPSO with DEE is 72 % and that of diesel is 76.5%. This is due to fact that complete combustion of fuel which enhances the combustion temperature.

CONCLUSION

A single-cylinder compression ignition engine was operated successfully on neat TPSO and TPSO with DEE injection. The following conclusions are drawn on the basis of the experimental results at 3.5 kW load:

- Mixing of 5%DEE with TPSO increases the brake thermal efficiency. The brake thermal efficiency is 34.9% with 5% of DEE, with neat TPSO it is 28.2%, and All biofuels had highest value of combustion duration compared to that of diesel.

On the whole, it is concluded that DEE mixed TPSO can be used as a fuel in diesel engines because combustion characteristics on the engine was significantly improved.

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