Comparison and Evaluation of Performance and Emission Characteristics of Four Stroke Diesel Engine with Neem and Cotton Seed Bio Diesels

Dr.V. Naga Prasad Naidu, Prof. V. Pandu Rangadu

***Abstract*— In recent years the research for alternative fuels has become inevitable due to fast depletion of fuels and huge demand for diesel in transport, power and agricultural sectors. One of the best alternatives is Bio Diesels obtained from different Vegetable oils. The present study focuses on Evaluation of performance and emission characteristics of a single cylinder four stroke diesel engine with two different biodiesels namely Neem oil and Cotton seed oil separately. The performance is compared on the basis of brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature and emissions of hydrocarbons and oxides of nitrogen. This study reveals that the performance of the engine with these biodiesels differ marginally from diesel and hydrocarbon emissions are less than diesel. It is also observed that the cotton seed oil showing better performance and emission characteristics as compared with Neem oil.**

***Keywords*—Bio Diesel, Cotton seed oil, Emissions, Hydro Carbons, Neem oil.**

I. INTRODUCTION

In the scenario of increasing industrialization and motorization of the world has led to a steep rise in the demand for petroleum products. If this situation continues there is every chance for the scarcity of petroleum products. A major solution to reduce this problem is to search for an alternative fuels. Vegetable oils can be an important alternative to the diesel oil, since they are renewable and can be produced in rural areas[1]. The inventor of diesel engine Rudolpf diesel predicted that the plant based oils are widely used to operate diesel engine. The bio diesel has great potentials as alternative diesel fuel[2]. But use of pure bio diesel can cause numerous engine related problem such as injector choking, piston deposit formation and piston ring sticking due to higher viscosity and low volatility of bio diesel[3]. Transesterification of bio diesel provides a significant reduction in viscosity, thereby enhancing their physical and chemical properties and improve the engine performance. Technical specifications of the engine

In this work experiments were conducted on 4 stroke, single cylinder, C.I engine (Kirloskar Oil Engineers Ltd., India) of maximum power-3.68 KW with AVL smoke meter and Delta 1600 S gas analyser.

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II. MATERIAL & METHODS

In the present work engine tests were conducted with Neem and Cotton seed Bio Diesels separately to evaluate performance and emission characteristics. Neemoil is a vegetable oil produced from neem seeds of neem tree. Neem (Azadirachta indica) is a tree in the mahogany family Meliaceae which is abundantly grown in varied parts of India. Neem plant is traditionally used for agricultural and medicinal purposes. These can grow on poor soils and areas of low rainfall. Neem seeds obtained from neem tree are de-pulped, sun dried and crushed for oil extraction. The seeds have 45% oil which has high potential for the production of biodiesel[4]. Cottonseed oil[5] is extracted from cottonseed. Cotton has long been known as nature's unique food and fiber plant. It produces both food for man and feed for animals in addition to a highly versatile fiber for clothing, home furnishings and industrial uses. Cottonseed oil has a ratio of 2: 1 of poly n saturated to saturated fatty acids and generally consists of 65-70% unsaturated fatty acids including 18-24% monounsaturated (ole ic) and 42-52% polyunsaturated (linoleic) and 26-35% saturated (palmitic and stearic)6. The various properties of the above bio diesels7 are presented in table 1.

TABLE I
PROPERTIES OF FUELS USED

Properties	Cotton seed oil	Neem OIL	Diesel
Density (kg/m3)	874	912	830
Calorific Value (kJ/Kg)	40000.32	39100	43000
Viscosity @400C(cSt)	4	5.2	2.75
Cetan Number	49.51-50	48	51
Flash Point (^oC)	70-110	130	74

III. Results and Discussions

A. Brake thermal Efficiency

The Figure 1 shows the variation of brake thermal efficiency with break power output. The brake thermal efficiency graph represents very similar trends for all the fuels. In general the thermal efficiency depends on the combustion process which is a complex phenomenon that is influenced by several factors such as design of combustion chamber, type of injection nozzle, injection pressure, spray characteristics and fuel characteristics such as cetane number, volatility, viscosity, homogeneous mixture formation, latent heat of vaporization, calorific value etc.

It is evident that diesel fuel has the higher brake thermal efficiency compared to biodiesels. The cotton seed oil has the highest thermal efficiency because of its calorific value and viscosity as compared with Neem oil. With the higher calorific value the amount of heat produced in the combustion chamber is more, further the combustion is complete and produced higher temperatures. The efficiency of diesel is 29.18%, Neem oil is 27.4% and for the cotton seed oil it is 28.2%.

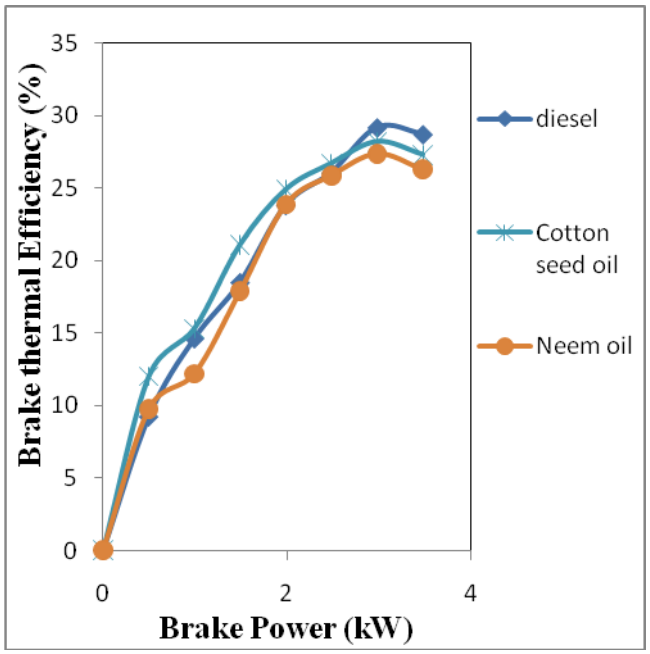

Figure 1. Variation of Brake thermal Efficiency with power output

B. Brake specific Fuel Consumption

The variation of brake specific fuel consumption (BSFC) with break power is shown in Figure 2. The BSFC reduced with the load for all the fuels. The BSFC for all the bio diesels are higher than diesel fuel. The specific fuel consumption is increased by 11.36% and 5.31% respectively with Neem oil and cotton seed oil compared with the diesel fuel. The BSFC is increased with increasing load because of the injection of less quantity of fuel due to the higher viscosity and lower heating value. The oxygenated biodiesels may lead to the leaner combustion resulting in higher BSFC.

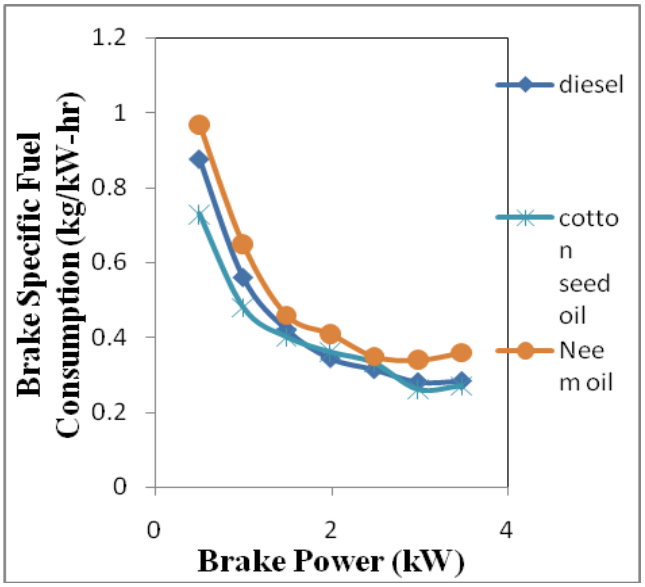

Figure 2 Variation of brake specific fuel consumption with power output

C. Exhaust Gas Temperature

The exhaust gas temperature in the combustion chamber depends on the calorific value, latent heat and viscosity of the fuel injected. The exhaust gas temperature increases with the load for all the fuels. It is observed from the Figure 3 that due to the higher viscosity less quantity of bio diesel is injected into the combustion chamber which forms into leaner mixture and makes the combustion insufficient. This reduces the combustion chamber temperature and in turn exhausts gas temperature. The exhaust gas temperature for the diesel at the rated load is 285^{0}C, for Neem oil 250^{0}C and for cotton seed oil it is 265^{0}C. Though the viscosity for the Neem oil and Cotton seed oil are higher it is compensated by the calorific value of the fuels.

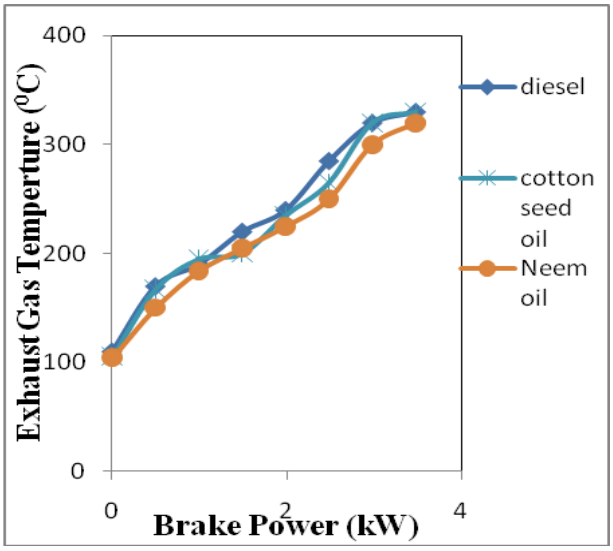

Figure 3 Variation of Exhaust gas temperatures with power output

D. Volumetric Efficiency

The Figure 4 depicts the variation of volumetric efficiency with power output. The volumetric efficiency of the diesel engine mainly depends upon the combustion chamber temperature. The increase in the chamber temperature increases the intake air temperature and consequently reduces the mass of air drawn in each cycle, further the volumetric efficiency decreases. It is observed that due to the less amount of bio diesel in the chamber and lower temperatures in the combustion chamber the volumetric efficiency dropped. The properties of cotton seed oil is nearer to the diesel, so the drop in efficiency is marginal compared to diesel. There will be an undesirable effect on the power output with the drop in volumetric efficiency. So for the diesel engine with bio diesel the power output is lower than normal engine

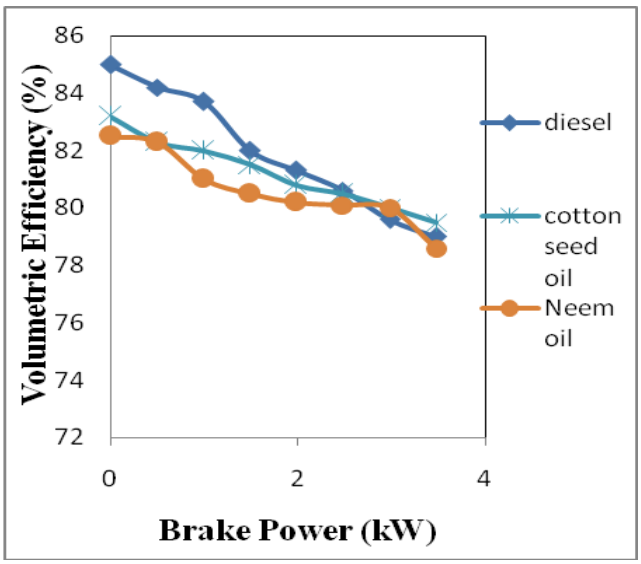

Figure 4 Variation of the volumetric efficiency with power output

E. Smoke Density

The variation of the smoke densities with power output is shown in Figure 5. The smoke opacity emissions increased with the increase of engine load. This is compensated up to certain extent due to the absence of aromatics and presence of inherent oxygen molecules in the bio diesel. These oxygen particles helps to promote stable and complete combustion by delivering oxygen to the combustion zone of burning fuel by reducing locally rich region and limit primary smoke formation and lower smoke emissions. Higher smoke emissions at higher loads may be due to poor atomization of bio diesel. Higher viscosity and bigger size fuel molecules result in poor atomization of fuel. When compared to diesel the increase in smoke emissions is 28% for Neem and 16% for the cotton seed oil due its high viscous nature.

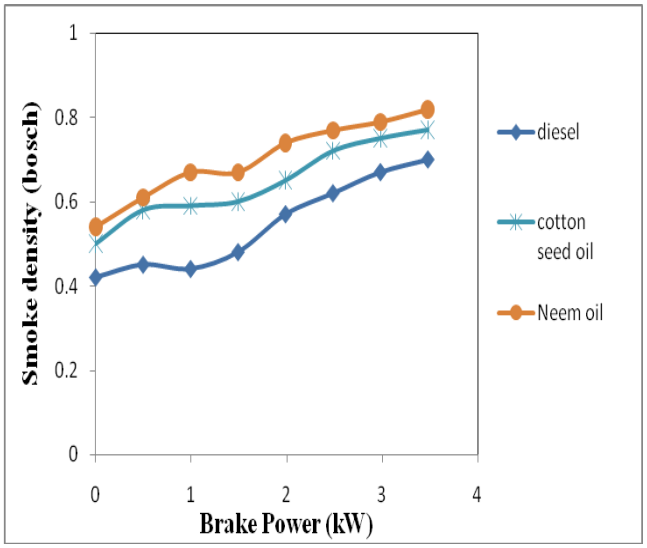

Figure 5 Variation of smoke density with power output

F. Hydrocarbon emissions (HC Emissions)

The variation of hydrocarbon emissions with break power is shown in Figure 6. The HC emissions depend upon mixture strength i.e. oxygen quantity and fuel viscosity in turn atomization. The HC emissions increase with increasing load as well as increasing the amount of bio diesel. There will be similar trends for all the fuels. Lower heating value leads to the injection of higher quantities of fuel for the same load condition. More the amount bio diesel leads to more viscosity. Viscosity effect, in turn atomization, is more predominant than the oxygen availability, either inherent in fuel or present in the charge. When compared to diesel, the oxygen availability in the bio diesels is more. So the emissions are less than diesel. It is observed from the figure that the decrease in hydro carbon emissions with cottonseed oil is more compared to Neem oil.

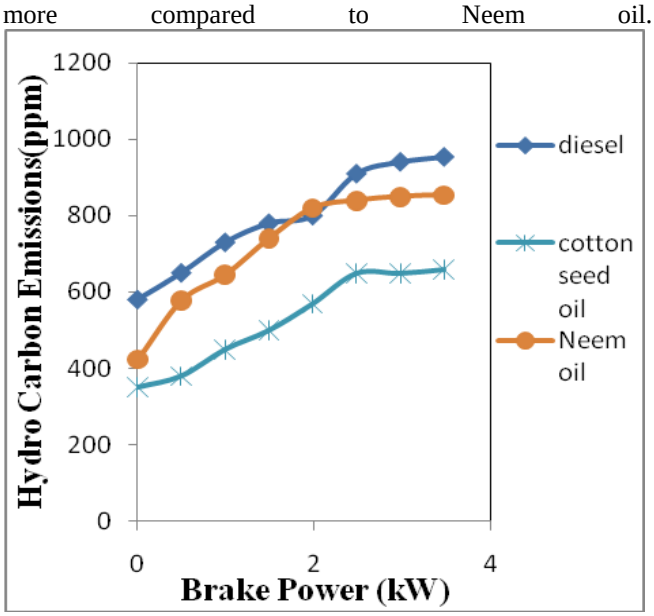

Figure 6 variations of hydrocarbon emissions with power output

G. Carbon Monoxide Emissions (co emissions)

The variation of carbon monoxide emissions for is illustrated in Figure 8. With the higher combustion chamber temperatures, the combustion in the engine is more complete and the oxidation of carbon monoxide is also improved. Hence carbon monoxide present in the exhaust due to incomplete combustion reduces drastically. Due to the lower calorific value and higher viscosity of bio diesel, the combustion in the diesel engine is insufficient. Thus the temperature produced in the chamber is less and in turn increases the CO emissions. But the oxygen presents in the bio diesel acts as a combustion promoter during the combustion process, which results better combustion and compensate the increase in the emissions.

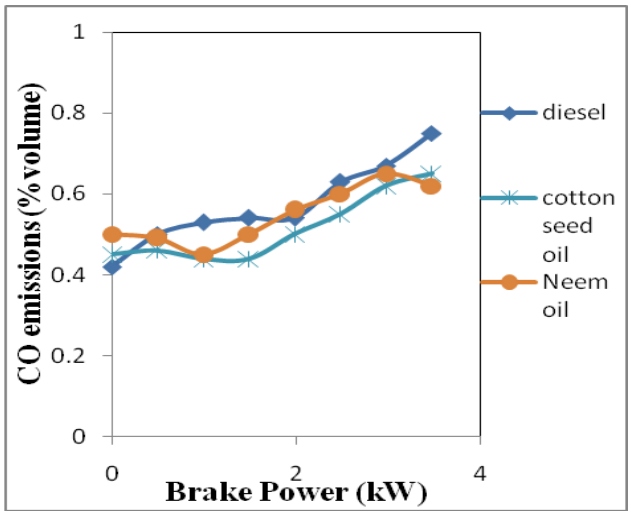

Figure 7 Variation of CO Emissions with Power output

H. Nitrogen oxide Emissions

The variation of Nitrogen oxide emissions oils is illustrated in Figure 8.

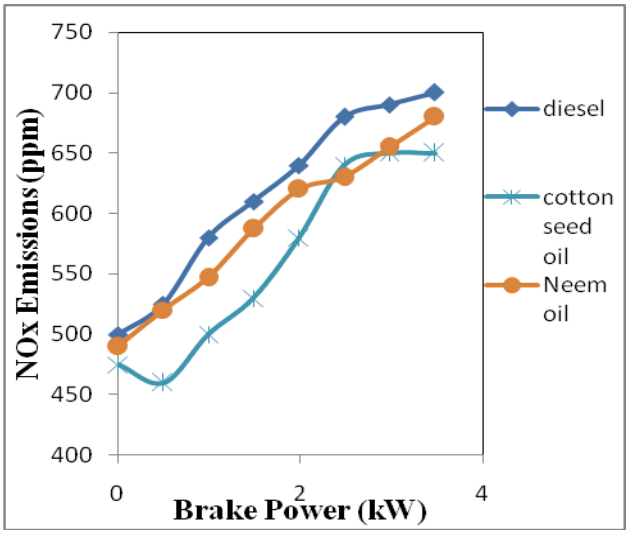

Figure 8 Variation of NOx emissions with power output

The NOx emissions are highest for diesel fuel compared to bio diesels. The percentage decrease in NOx emissions with cotton seed oil it is about 5.88% and for Neem it is about 10.47%

IV. Conclusions

The following conclusions are drawn based on the experimental results of the above work:

- The brake thermal efficiency of the engine depends majorly on the heating value and viscosity. The cotton seed oil is having brake thermal efficiency nearer to diesel.
- With the higher combustion rate, the temperature inside the engine and in turn in the exhaust increases
- The Hydrocarbon emissions are less than diesel fuel
- The CO emissions depends on the combustion chamber temperature and it is less with bio diesels
- The NOx emissions increase with the higher temperatures in the chamber. With the bio diesels due to its lower heating values and higher viscosity the temperature in the chamber is less and in turn emissions are less than diesel fuel.

It is concluded that out of the two bio diesels cotton seed oil is best oil and the efficiency is also nearer to the diesel. So the cotton seed oil can be used as alternative to diesel.

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