International Journal of Mechanics and Thermodynamics.
ISSN 2278-361X Volume 6, Number 1 (2015), pp. 1-10

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Evaluation of Performance and Emission Characteristics of Flax Oil Ethyl Ester with Ignition Improver on Diesel Engine and Comparison With Jatropha

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Abstract

Increased energy demand and the concern about environment friendly technology, renewable bio-fuels are emerged as better alternative to conventional fuels. In the present study flaxseed oil was used as alternative source for diesel engine fuel and the results were compared with baseline data of neat diesel and also jatropha.

The experimental investigations have been carried out on a four stroke single cylinder diesel engine for the performance and emissions characteristics of different blends of flaxseed oil ethyl ester. The results yielded were compared with jatropha and diesel fuels. In order to improve the process of ignition THF is added as an ignition improver and the performance tests were conducted by varying input parameters like air fuel ratio and air preheat temperature. There has been a considerable increase in the engine efficiency and reduction in emissions.

I. INTRODUCTION

The Energy comes in a variety of renewable forms like wood energy, wind energy, solar energy, ocean water power, geothermal energy; bio energy generated by bio fuels is viewed as a strong source of energy in the coming years. The Energy is also available in the nonrenewable form of fossil fuels that is oil, natural gas and coal, which provide almost 80% of the world's supply of primary energy. Use of these fossil fuels is a major source to cause pollution of land, sea and the entire atmosphere.

For the last two centuries it is coming to know that all the unprecedented industrialization, power productions and transportation are mainly driven by fossil fuels and they have changed the face of this planet.

India is the fourth largest consumer of energy in the world after USA, China and Russia, but it is not endowed with abundant energy resources.

Despite the recent global economic slowdown, India's economy is expected to continue to grow at 6 to 8 percent per year in the near term, the strong economic growth and a rising population, growing infrastructural and socioeconomic development will stimulate an increase in consumption across all major sectors of the Indian economy. India imports about 80% of its crude oil requirement for domestic production of oil is inadequate to keep pace with the rising consumption of petroleum products. The indiscriminate extraction and consumption of fossil fuels results in a reduction of petroleum reserves and also the emissions from the fossil fuels are considered as a major source to the environment pollution.

Hence there is a need to find some alternate fuel, which can provide compensation for the depletion of the conventional petroleum resources and which can be produced from the available local resources. Such alternative fuels are alcohol, ethanol, biodiesel, vegetable oils etc. The present experimental work is carried out using flaxseed oil (Linum Usitatissimum) as raw fuel or raw material as biodiesel production. The India is a large importer of vegetable oils so the edible oils cannot be used for the production of the biodiesel. The India also has a wide range of potential to become a leading biodiesel producer in the world since biodiesel can be harvested and sourced from non edible oils such as Jatropha, Curcus, Pongamia Pinnata, Neem, Mahua, Castor, flaxseed et. Flaxseed oil is a non edible vegetable oil and is considered as a potential alternative fuel for the CI engines. The Linum usitatissimum is known as Alasi oil in Hindi and it is also known as Flax seed oil in some countries. Flaxseed India is popular for its quality and it is also exported to the foreign countries. After Canada, China and Russia the India is the fourth largest country in the production of large quantities of flaxseed.

Fig. 1 Flaxseeds, Its Flowers and Plant

Table 1:- Properties of Flaxseed oil and Jatropha with diesel

Properties	Diesel	Flax seed oil	jatropha
Density (gm/cc)	0.83	0.89	0.92
Viscosity (cst)	3.22	33.48	42.76
Flash point (^{o}c)	50	121	214
Fire point (^{o}c)	66	187	256
Calorific value (kJ/kg)	42500	39349	39700
Specific gravity	0.83	0.89	0.91

II. BIODIESEL PRODUCTION

Biodiesel is oxygenated compounds, defined as the mono alkyl esters of long chain fatty acids are also called methyl esters derived from lipid feedstock for example vegetable oils, animal fats or even waste cooking oil. Pure oils are not suitable for diesel engines because they can cause the carbon deposits and pour point problems and they can also cause the problems like engine deposits, injector plugging, or lube oil gelling. So to use the oils in the diesel engines, they are chemically treated and that chemical process is known as transesterification. The transesterification which is also known as alcoholysis is the reaction of fat or vegetable oil with an alcohol to form esters and glycerol. Mostly a catalyst is also used to improve the rate and yield of the reaction. Since the reaction is reversible in nature, excess alcohol is used to shift the equilibrium towards the product. Hence, for this purpose primary and secondary monohydric aliphatic alcohols having 1-8 carbon atoms are used. The chemical reaction of transesterification processes is shown below in fig. where R represents a mixture of various fatty acid chains depending on the specific oil in use. Subscript 3 represents the number of moles needed to satisfy the formation of ethyl esters.

A. Properties of flaxseed Oil and jatropha

The different properties of flaxseed oil and jatropha are tabulated in the Table 1. It can be seen in the table that the properties of the flaxseed oil is very closer to the diesel.

III. EXPERIMENTAL SETUP

The experimental test rig is 4-stroke diesel engine. It is a vertical, single cylinder, water cooled engine connect to eddy current type dynamometer for loading. The test rig engine consists of the fuel supply system for both diesel and biodiesel, lubricating system, water cooling system and various sensors attached and integrated with the computerized data acquisition system for the measurement of load, cylinder pressure, injection timing, position of crank angle etc. The fig.2 below shows the complete test rig of 4-stroke diesel engine.

Fig 2:- 4- Stroke diesel engine

IV.EXPERIMENTAL SET UP FOR AIR-PREHEATING

An air-preheater (APH) is a general term to describe any device designed to heat air before another process (for example, combustion in a boiler) with the primary objective of increasing the thermal efficiency of the process.

The object of the intake system is to deliver the proper amount of air and fuel accurately and equally to all cylinders at the proper time in the engine cycle. Flow into an engine is pulsed as the intake valves open and close, but can generally be modeled as quasi-steady state flow. The intake system consists of an intake manifold, a throttle, intake valves, and either fuel injectors or a carburetor to add fuel. Fig 3 shows the arrangement of air-preheating on 4-stroke diesel engine.

Fig 3:-(a) Heater (b) 4- Stroke diesel engine

V. RESULTS AND DISCUSSION

1) BRAKE THERMAL EFFICIENCY

The variation of brake thermal efficiency with brake power for different fuels is presented in Fig 4. In all cases, it increased in power with increase in load. with increase with brake power.. The maximum thermal efficiency for F23E6HTHF2 at full load 31.48% was nearer to diesel (32.16%). The same blend is preheated at constant temperature there is increase in efficiency that is (48.2%) which is higher than the diesel and compared to jatropha blend is JOEETHF2 at full load (30.22%) the same blend is preheated at full load (41.29%).

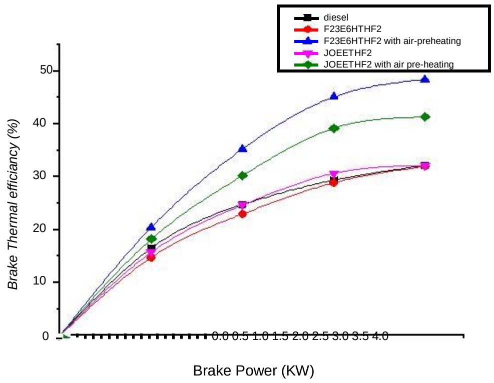

Fig.4 Variation of Brake Thermal Efficiency with Brake power

2) MECHANICAL EFFICIENCY

The comparison of Mechanical efficiency for various biodiesel blends with respect to brake power shown the Fig 5. From the plot it is observed diesel and its blends like F23E6HTHF2 and JOEETHF2 nearly equal at full load conditions. But considerable improvement in mechanical efficiency was observed by the blend F23E6THF2 with air pre-heating is 70.58% because of lowest frictional powers compared to diesel.

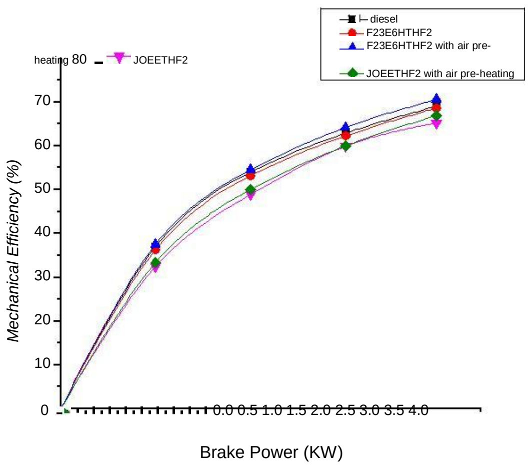

Fig.5 Variation of Mechanical Efficiency with Brake power

3) BRAKE SPECIFIC FUEL CONSUMPTION

The variation in BSFC with brake power for different fuels is presented in Fig.6 Brake-specific fuel consumption (BSFC) is the ratio between mass fuel consumption and brake effective power, and for a given fuel, it is inversely proportional to thermal efficiency. It can be observed that the BSFC of 0.263kg/kW-hr were obtained for diesel and 0.251 kg/kW-hr F23E6HTHF2 at full load. It was observed that BSFC decreased with the increase in concentration of flaxseed oil in diesel. The BSFC of Bio-diesel is decreases to jatropha that is JOEETHF2 is 0.23% as compared with diesel at full load condition.

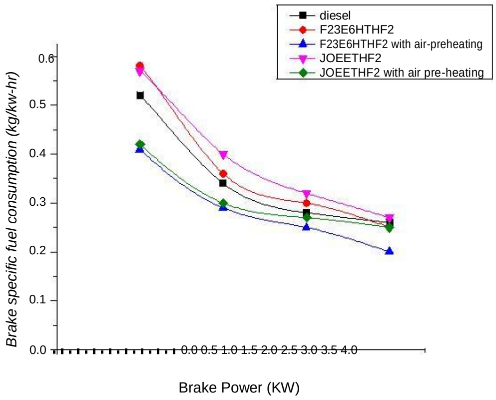

Fig.6 Variationof Brake Specific Fuel Consumption with Brake power

4) INDICATED SPECIFIC FUEL CONSUMPTION

The variation of Indicated Specific Fuel Consumption with brake power is shown in Fig 7. It is observed that from the graphsF23E6THF2 line varies similar with the diesel. At full load ISFC of diesel is 0.167 kg/kW-hr and for JOEETHF2 are 0.171 kg/kW-hr. The ISFC of bio-diesel is increases up to 2.39% as compared with diesel at full load condition.

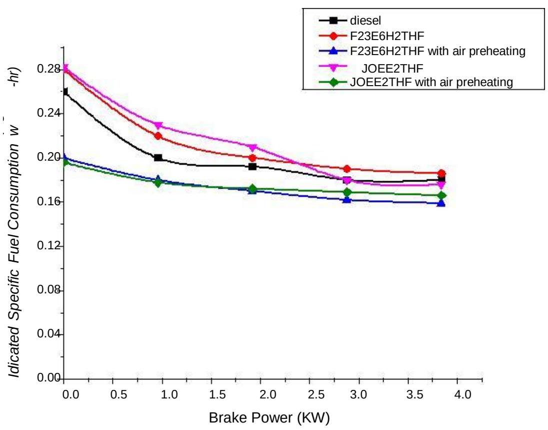

Fig 7 Variation of Indicated Specific Fuel Consumption with Brake power

5) VOLUMETRIC EFFICIENCY

The variation of volumetric efficiency with Brake Power is shown in Fig 8. The actual volume of air which is inducted for the combustion of F23E6THF2 is less with respect to stoichiometric A/F ratio and therefore the volumetric efficiency of the engine is slightly decreased when F23E6THF2 is used as fuel.

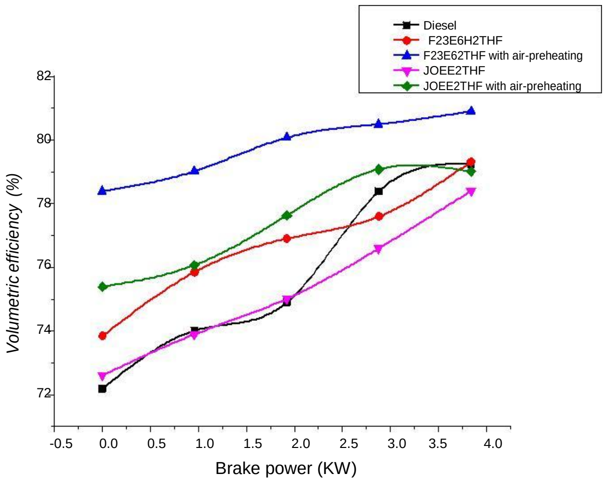

Fig 8 Variation of Volumetric Efficiency with Brake power

EMISSION ANALYSYS

6) CARBON MONOXIDE (CO)

The comparison of carbon monoxide for various biodiesel blends with respect to brake power shows in Fig 9. For F23E6HTHF2 carbon monoxide emission level is lower than that of diesel and also with jatropha, in order to gives 10% to 20% extra oxygen. Due to the presence of extra oxygen, additional oxidation reaction takes place between O_2 and CO.The decreased CO emissions is 40% than diesel fuel for F23E6HTHF2 with air pre-heating at full load.

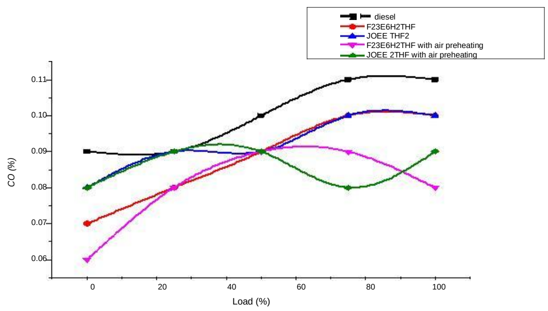

Fig 9 Variation of Carbon monoxide with Load

7) CARBON DIOXIDE (CO2)

The variation of carbon dioxide with brake power is shown in Fig 10. The CO_2 emissions from a diesel engine indicate how efficiently the fuel is burnt inside the combustion chamber. The ester-based fuel burns more efficiently than diesel. Therefore, in case of F23E6THF2, the CO_2 emission is greater. At full load diesel contains 6.0 % of CO_2 emissions where as in case ofF23E6THF2 it is 6.40 %.The increase in CO_2 emissions is 6.66%.

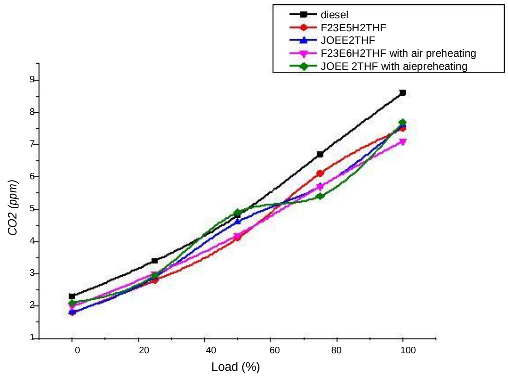

Fig 10 Variation of Carbondiaoxide with Load

8) OXIDES OF NITROGEN (NO_X)

Variation of NOx with engine brake power for different fuels tested is presented in Fig 11. The nitrogen oxides emissions formed in an engine are highly dependent on combustion temperature, along with the concentration of oxygen present in combustion products. The amount of NOx produced for F23E6THF2 is 471ppm, where as in case of diesel fuel is 490 ppm for diesel fuel.

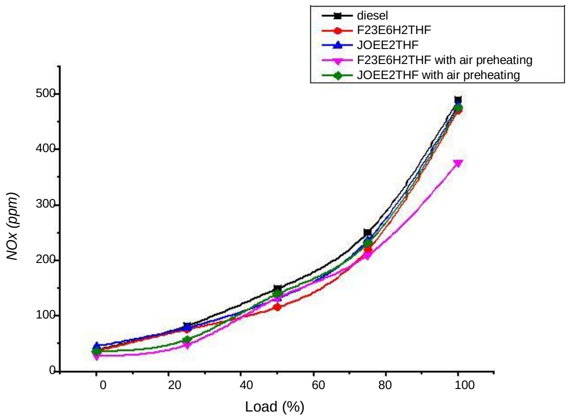

Fig 11 Variation of Oxides of nitrogen with Load

9) HYDROCARBONS EMISSIONS (HC)

The hydrocarbons (HC) emission trends for blends of ethyl ester of linseed oil and diesel are shown in Fig.12 That the HC emissions decreased with increase in brake power for all biodiesel blends (F23E6THF2, F23E6THF2 with air pre-heating) at all loads. But in case of diesel fuel HC emissions are increases with load, because of there is no oxygen content present in diesel fuel. At full load diesel contains 58 ppm where as in case of F23E6THF2 it is 99 ppm at same load.

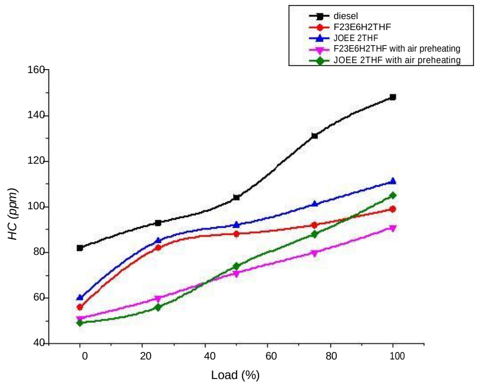

Fig 12 Variation of Hydrocarbons with Load

10) SMOKE DENSITY

The variation of Smoke density emissions with brake power for diesel fuel, biodiesel-blends is shown in the Fig 13. The smoke is formed due to incomplete combustion in engine. The smoke density is lower for F23E6THF2 compared to F23E6THF2 with air pre-heating and D100.The maximum smoke density recorded for the diesel was 83.57 HSU, 62.96 HSU for L10 61.9 HSU for JOEETHF2and 67.16 HSU for F23E6THF2 at maximum load. The decrease in smoke density of F23E6HTHF2, F23E6HTHF2 with air pre-heating is 24.6%, 25.9% respectively compared with diesel fuel at full load.

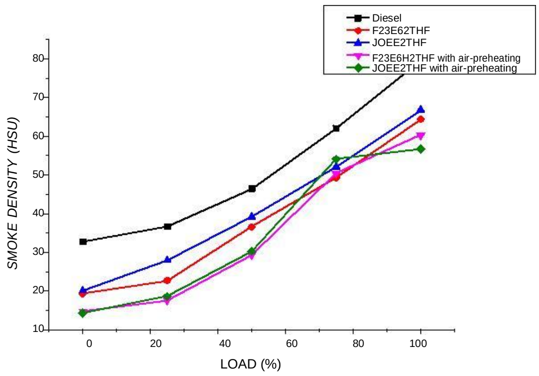

Fig 13 Variation of Smoke Density with Load

CONCLUSIONS

The maximum brake thermal efficiency for F23E6HTHF (31.96%) which is nearer to diesel but lower than the JOEETHF2 blend. Further the brake thermal efficiency increased with air pre-heating is F23E6HTHF2 (48.42%) compared to JOEETHF2.

Brake specific fuel consumption is decreases in for F23E6HTHF2fuels with added ignition improver compared to diesel and JOEETHF2. The decreased in BSFC in 4.38% and 8.74%. By air pre-heating the fuel consumption for F23E6HTHF2 is decreased when compared to without air-pre-heating for F23E6HTHF2.

Significant reductions were obtained in unburned hydrocarbons emissions with F23E6HTHF2 blend compared with JOEETHF2 and diesel. Unburned hydrocarbons were decreased by 5.25%, 18.96% compared to JOEETHF2 and diesel at maximum load of the engine. Also the unburned carbons are further decreased by 2.22% pre heating of air for F23E6HTHF2 compared to JOEETHF2 and diesel.

The interesting things were obtained NOx emissions were decreased withF23E6HTHF2 compared to JOEETHF2 and diesel. NOx emissions were decreased by 2.29% with F23E6HTHF2compared to JOEETHF2 and diesel. Further it was decreased due to pre-heating of air by 4.6%.

The significant decrease in CO2 emissions were obtained withF23E6HTHF2 as compared to JOEETHF2 is 50%, 60% compared with diesel. But slightly increases at full load for air pre-heating of F23E6HTHF2.

The marginal increases in smoke densities compared with JOEETHF2 and diesel. The increment was in the order of 30.31% and 43.31% respectively. By air pre-heating there is increase of smoke density for 2.48% at full load compared to F23E6HTHF2 and diesel.

Maximum reduction in CO emissions with F23E6HTHF2 by air pre heating was obtained. The order of decrees in 0.11% 0.12% compared with JOEETHF2 and diesel.

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