Performance and Emission Analysis of a Four Stroke Diesel Engine Fueled with Hibiscus Oil Ethyl Ester

G. V. Prudhvi Dilip[1]
[1]M-Tech Student
Mechanical engineering Department,
Lakireddy Balireddy College of Engineering,
Mylavaram, AP , India

Dr. K . Appa Rao[2,]
[2]Professor
Mechanical Engineering Department,
Lakireddy Balireddy College of Engineering,
Mylavaram, AP, India

Abstract: **Now a day the usage of natural resource such as petroleum and diesel are more and get depleted gradually. So the need for alternatives to the mineral oils with renewable sources of energy which are available in abundance and at a low cost in comparison with the mineral oils. Raw crude Hibiscus oil is taken and transesterification process is done for obtaining hibiscus ethyl esters and to get nearest properties to diesel for testing. Then ethyl esters of hibiscus oil with different blends like H10, H20, H30, and H40. Now the performance and emission parameters are carried out at constant speed 1500rpm and compared with the base line data taken by the values of the diesel. Analyzed "Brake specific fuel consumption, Brake thermal efficiency, Brake power, CO, CO2, HC as compared to diesel. From the experiment analysis the optimized blend obtained is H30.**

Key Words: Biodiesel; Transesterification; Blends; Alternate fuel.

I. INTRODUCTIOIN

In the modern day world there is the crisis of the petroleum fuel. The petroleum reserves have been depleting now a days and there is a rise in the petroleum prices. So the urge of the alternate fuels which are renewable resource is becoming more and more. 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. Vegetable oils can be used as an alternative to diesel in compression ignition engine. The use of vegetable oils in a C.I engine results in low CO and HC emissions compared to conventional diesel fuels. Now in the developing countries like India the contribution of the bio diesels such as jatropa, neem, mahua oils is increasing day by day. In my experiment I have taken the Hibiscus oil.

Transesterification process is done for resolving the demerits of the properties of bio diesel and blending is done for the decreasing of the viscosity of the bio diesel. Hibiscus is not that much developed in our country but it is an upcoming agricultural crop.

Stalin et al. [1] He used karanja oil as an alternative fuel. He conducted the experiment by constant load of 20N was used throughout the entire experiment at engine speeds of 600, 1000, 1400 and 1800 rpm. He used the blends of B10, B20, B30 and B40.For him optimal blend is B40.

S.Ehmusaltun et al. [2] in this investigation experiments are conducted on four stroke, four cylinder, and natural aspirated water cooled diesel engine with waste cooking oil and inedible animal tallow methyl esters. The BSFCs for both of the biodiesels were higher than that of diesel fuel. The comparison of decreases in CO emissions between inedible animal tallow and waste cooking oil biodiesels indicates that inedible animal tallow is more effective than waste cooking oil.

S S Ragit et al [3] they were conducted experiments using neem oil methyl ester (NOME) was tested in 4-stroke single cylinder water cooled diesel engine. Brake thermal efficiency of NO 100 has been found 63.11% higher than that of diesel at part load whereas it reduces 11.2% with diesel fuel at full load. As NOME is concerned, HC is reduced at all load condition, whereas smoke is also reduced at full load condition. NOx has reduced slightly at all load condition, and EGT showed increasing trend at full load condition. Other emissions (CO, CO2 and O2) do not contribute bad effect on engine. Thus, NOME can be a substitute for diesel fuel in diesel engine.

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.1 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. In this process the raw crude Hibiscus oil is taken and mixed with the ethyl alcohol and the catalyst potassium hydroxide is used for the fast process. Then it is heated for a while and then the glycerol and the biodiesel is separated by distillation.

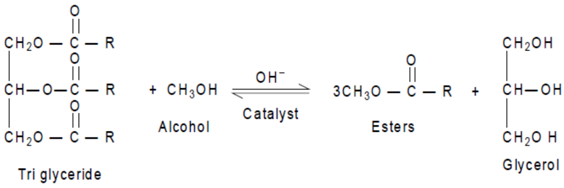

Fig. 1 Mechanism of Transesterification Reaction

A. *Properties of Hibiscus oil*

Table1: Comparison of Properties between Crude Hibiscus oil and Diesel

Properties	Hibiscus oil	Pure Diesel
Density (kg/m^3)	746.9	843
Viscosity at 40^{o}c (centi stokes)	4.26	4.3
Flash point (^{0}C)	130	50
Specific Gravity	0.89	0.83
Cetane number	32	50-55
Calorific value(KJ/kg)	36500	42500

III. EXPERIMENTAL SETUP

The experimental test rig is a VCR engine that is a Variable Compression Ratio 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 VCR engine. Performance and emission test were carried out in diesel engine with different blends. All the performances were measured at constant speed 1500rpm at different loads 0%, 25%, 50%, 75%, and 100%. Then the graphs are plotted according to the values with the different blends H10, H20, H30, and H40 which are obtained and compared to the base line data of the diesel values.

Fig. 2 Four Stroke Single Cylinder Water Cooled Diesel Engine

Table2: Specifications of the Engine

BHP	5HP
Speed	1500rpm
Bore	80mm
Stroke	110mm
Compression ratio	16.5:1
Orifice diameter	17mm
Method of start	Crank start
Make	Kirloskar
Type of Ignition	Compression Ignition

IV. RESULTS AND DISCUSSSION

a) *Brake Thermal Efficiency*

The variation of brake thermal efficiency with brake bower is shown in Fig.3. From the plot it is observed as the BP increases there is considerable increase in the BTE. The BTE of diesel at full load is 32.82% while the blends of H30 are 33.77%, among three the maximum BTE is 33.77% which is obtained for H30. The BTE of HOEE is increases as compared with diesel at full load condition. Almost all blends show slightly better BTE than diesel at higher load conditions. The higher thermal efficiencies may be due to oxygenated fuel gives a better fuel combustion delivering improved thermal efficiency and the additional lubricity provided by the fuel Blends

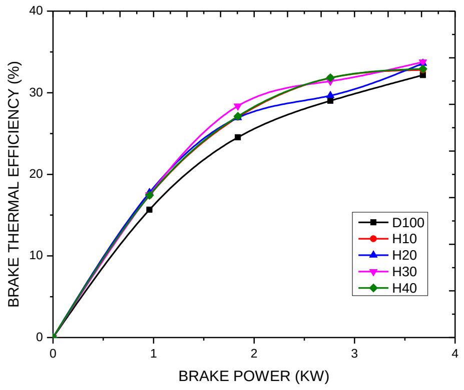

Fig. 3 Variation of Brake power with Brake thermal efficiency

b) Mechanical Efficiency:

The variation of mechanical efficiency with brake power is shown in Fig. 4. from the plot it is observed the diesel and various blends of HOEE like H10, H20, H30 and H40 decreases at lower load conditions and slightly equal at full load conditions. At full load condition the mechanical efficiencies of H30 shows slightly better than the diesel.

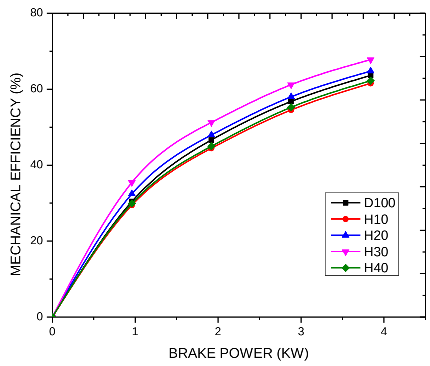

Fig. 4 Variation of Brake Power with Mechanical efficiency

c) Brake Specific Fuel Consumption:

When two different fuels of different heating values are blended together, the fuel consumption may not be reliable, since the heating value and density of the two fuels are different. In such cases, the brake specific fuel consumption (BSFC) will give more reliable value. It can be observed from the fig. 5 that the BSFC for HOEE is lower at all blends as compared to that of diesel fuel at full load. The availability of the oxygen in the Hibiscus ethyl ester-diesel fuel blend may be the reason for the lower BSFC. In the case of lower load conditions, the incomplete mixture of high viscosity HOEE may lead to incomplete combustion and require additional fuel air mixture to produce the same power output as that of diesel fuel.

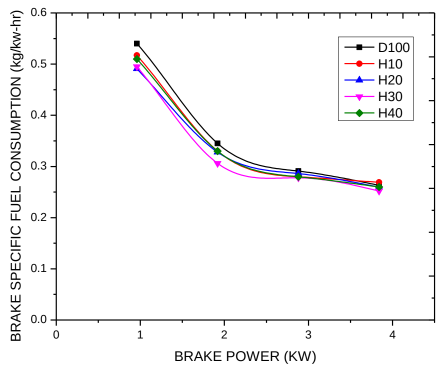

Fig. 5 Variation of Brake Power with Brake Specific Fuel Consumption

d) Hydrocarbons:

The hydrocarbons (HC) emission trends for blends of ethyl ester of linseed oil and diesel are shown in Fig.6. That the HC emissions decreased with increase in brake power for all biodiesel blends (H10, H20, H30 and H40) 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. The presence of oxygen in the fuel was thought to promote complete combustion.

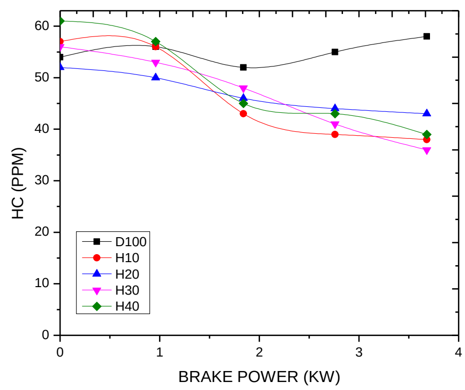

Fig. 6 Variation of Brake Power with Hydrocarbons

e) Carbon dioxide:

The variation of carbon dioxide with brake power is shown in Fig.7. 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 HOEE, the CO_2 emission is greater. At full load diesel contains 6.0 % of CO_2 emissions where as in case of H30 it is 6.40 %. The CO_2 emissions increased with load for all the fuel modes. At varying loads, the oxygen content in the HOEE improves the combustion process, which leads to a complete combustion and hence increased CO_2 emission than that of diesel.

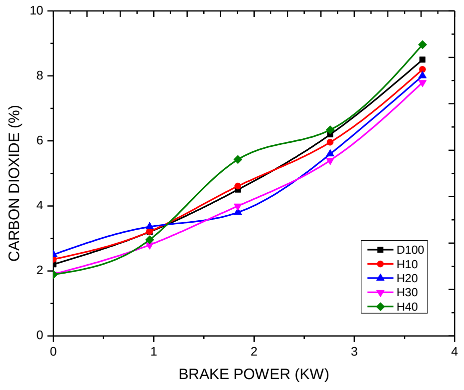

Fig. 7 Variation of Brake Power with Carbon dioxide

f) Smoke Density:

The variation of Smoke density emissions with brake power for diesel fuel, biodiesel-blends is shown in the Fig. 8. The smoke is formed due to incomplete combustion in engine. The smoke density is lower for H30 compared to D100. In case of HOEE, the smoke emission is low. This is because of better combustion of HOEE. The smoke density increased with the load for diesel fuel and diesel blends.

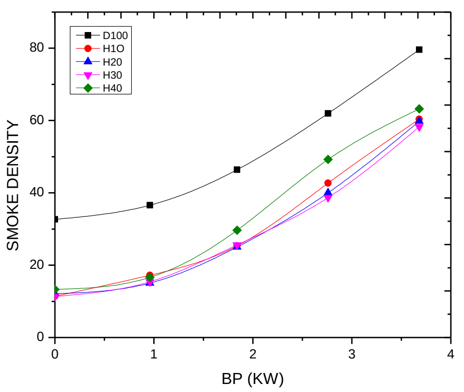

Fig. 8 Variation of Brake Power with Smoke density

I. CONCLUSIONS

The performance characteristics of diesel and biodiesel blends were investigated on single cylinder water cooled diesel engine. The conclusions of this investigation at full load are as follows:

The brake thermal efficiency increases with increase biodiesel percentage. Out of all the blends H30 shows best performance parameters. The maximum brake thermal efficiency obtained is 33.47% with H30 blend. The BSFC decreases with increasing Hibiscus oil blend and the mechanical efficiency also increases as we get 72.77%.

Also H30 blend shows the reduction in the emission characteristics such as CO2, NOx, hydrocarbons when compared with diesel. It will be a promising renewable energy source for sustaining the energy and less air polluted. Thus we conclude that the H30 is the optimum blend.

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