Experimental Investigation on 4-Stroke Single Cylinder Water Cooled Diesel Engine of Hibiscus Seed Oil Ethyl Esters Using Blend with 1-Hexanol

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Abstract- **Now-a-days the usage of conventional fuels such as petrol and diesel are increased and get depleted gradually and there is a need for suitable alternative fuels for IC engines. The most suitable among the available alternative fuels are in the form of alcohols and vegetable oils which are easily available and are renewable in nature besides being cost effective. The process used to make vegetable oils suitable for use in CI engines is to convert it in to biodiesel using Transesterification process. The Crude Hibiscus oil is converted to Hibiscus Oil Ethyl Esters (HOEE) by transesterification process by using ethyl alcohol. The biodiesel fuel properties such as viscosity and specific gravity of Hibiscus Oil Ethyl Esters are obtained. Experimental investigation is conducted on the single cylinder water cooled diesel engine with constant speeds with various loads using diesel base line data. In the second stage the experimental investigation has been carried out on same engine using Hibiscus Oil Ethyl Esters with different proportions H5, H15, H25, and H35 blends. The performance and emission parameters obtained by HOEE are compared with diesel and H15 is the optimum blend obtained. After finding optimum blend, the tests were conducted on the same engine with addition of 1-Hexanol at 5%, 10% and 15% on volume basis and evaluate its effects on diesel engine characteristics. The main purpose of fuel additives is to improve the combustion process and reductions of exhaust emissions. Finally, the experimental outcomes are analyzed with the diesel.**

Index Terms- **Bio-Desil, Low emission Oils, Alternate fuel, Effect of Ignition improver on C.I Engine.**

I. INTRODUCTION

Energy is essential for economic and social development, which in turn is linked to the improvement in the quality of life. Higher the energy consumed per individual, higher the standard of living. Most of the energy produced in the world emanates from fossil fuels formed by the vegetation and animals buried under the earth, hundreds of millions years ago. Human beings convert energy forms from less desirable to more desirable ones, *i.e.* from wood to heat and from fossil fuels to electricity – the most usable form of energy. Over the years, man has developed ways to expand his ability to harvest energy. At present, well developed coal mining technologies and high efficiency oil rigs for oil and gas production, lead to faster exploitation of fossil resources. Contextually, a simple representation of the energy system is shown in the Fig 1.

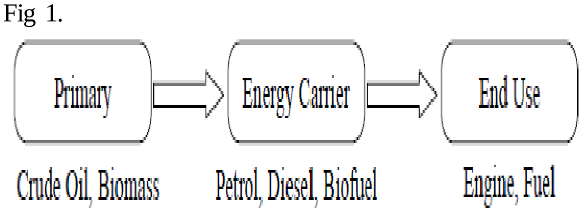

Fig: 1 Energy flow

Hydrocarbon fuels play an important role in the industrial development of most of the countries. These fuels play a major part in the transport sector and their consumption is steadily increasing. The intensity of fuel consumption is directly proportional to the development of the society.

Diesel engines have been widely employed in engineering machinery, automobiles and shipping equipment because of their excellent drivability and thermal efficiency. Diesel fuels are used in heavy trucks, city transport buses, locomotives, electricity generators, farm equipment, underground mining equipment etc. The energy generated from the combustion of fossil fuels has indeed enabled many technological advancements and socio–economic growth. However, it has simultaneously created many environmental concerns, which can threaten the sustainability of our ecosystem. The high demand for diesel in the industrial world and pollution problems caused by its widespread use make it necessary to develop renewable energy sources of limitless duration with a smaller environmental impact than those of traditional sources.

Therefore, to replace diesel fuel a renewable fuel is required and that could be biodiesel. Biodiesel is defined technically as 'a fuel comprised of mono alkyl esters of long-chain fatty acids derived from vegetable oils, animal fats or Non-edible oils like those derived from jatropha, pongamia, jojoba, Cashew Nut Shell, Castor and so on are promising feedstock especially in developing countries where edible oils are in short supply. The major advantage of all bio-fuels is their renewable nature, *i.e.* every year the output can be assured from the resources if properlymaintained whereas fossil fuel reserves dwindle year-by-year. Recovery fromthis mishap of trade imbalance is possible by cultivation of bio-fuel plantation.

II. PRODUCTION OF BIO-DISEL

There are so many investigations on bio-diesel production of non-conventional feeds tock's of oils have done in last few years. Overview of Transesterification process to produce biodiesel was given for introductory purpose. It is reported that enzymes, alkalis, or acids can catalyse process. Alkalis result in fast process. It is mentioned that catalysed process is easy but supercritical method gives better result. Adaptation of the vegetable oil as a CI engine fuel can be done by four methods Pyrolysis, Micro emulsification, Dilution, and Transesterification. Out of these in this study transesterification process is used.

A. Mechanical Press

The technique of oil extraction by using mechanical press is most conventional one. But oil extracted by mechanical presses needed further treatment of factorization and degumming. One more problems associated with conventional mechanical presses are, their design is suited for some particular seeds, and yield affected for other seeds.

B. Solvent Extraction Technique

It is the technique of removing one constituent from a solid by means of a liquid solvent also called leaching. The process may be employed either for the production of a concentrated solution of a valuable solid material or in order to free an insoluble solid, such as pigment from a soluble material with which it is contaminated. In this process, a chemical solvent such as n-hexane is used to saturate the crushed seed and pull out the oils. After completion of the extraction process these solvent is condensed and reclaimed.

There are many factors influencing the rate of extraction like particle size influences the extraction rate in a number of ways. The smaller the size the greater is the interfacial area between the solid and liquid, and therefore the higher is the rate of the transfer of material. The liquid chosen should be a good selective solvent and its viscosity should be sufficiently low for it to circulate freely.

Temperature also affects the extraction rate, in most cases; the solubility of the material which is being extracted will increase with temperature. Agitation of the solvent also affects, it increases the eddy diffusion and therefore increases the transfer of material from the surface of the particles.

The "Catalytic transesterification" process is the reaction of a triglyceride (fat/oil) with an Alcohol (e.g. methanol, ethanol or butanes) in the presence of some catalyst such as sodium hydroxide or potassium hydroxide to form esters and glycerol.

A triglyceride has a glycerine molecule as its base with three long chain fatty acids attached. The characteristics of the oil/fat are determined by the nature of the fatty acids attached to the glycerine. The nature of the fatty acids can in turn affect the characteristics of the bio-diesel.

The products of the reaction are the biodiesel itself and glycerol.

The Flow chart of transesterification process of HOEE is shown in Fig. 2

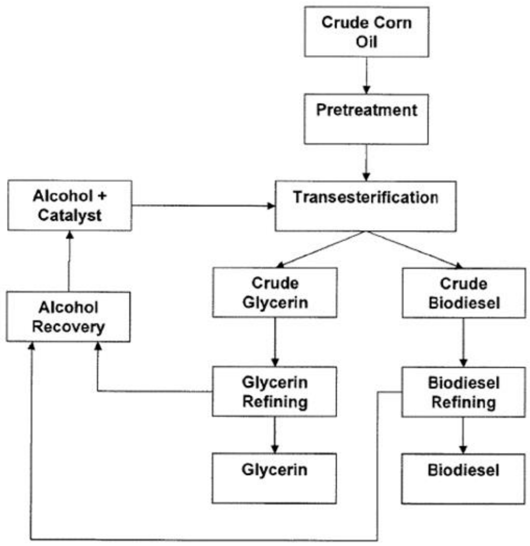

Figure.2: Steps followed in transesterification process

Transesterification is otherwise known as alcoholisms. It is the reaction of fat or oil with alcohol to form esters and glycerine. A catalyst is used to improve the reaction rate yield. Among these methods transesterification process is the best process to produce the cleaner and environmentally safe form of vegetable oils.

III. EXPERIMENTAL METHODOLOGY

Experimental set up consists of a water cooled single cylinder vertical diesel engine coupled to a rope pulley brake arrangement it shown in plate 4.6, to absorb the power produced necessary weights and spring balances are induced to apply load on the brake drum suitable cooling water arrangement for the brake drum is provided. A fuel measuring system consists of a fuel tank mounted on a stand, burette and a three way cock. Air consumption is measured by using a mild steel tank which is fitted with an orifice and a U-tube water manometer that measures the pressures inside the tank. For measuring the emissions the gas analyser is connected to the exhaust flow.

The engine was first operated on diesel fuel with no load for few minutes at rated speed of 1500 rpm until the cooling water and lubricating oil temperatures comes to certain temperature. The same temperatures were maintained throughout the experiments with all the fuel modes. The baseline parameters were obtained at the rated speed by varying 0 to 100% of load on the engine.

The diesel fuel was replaced with the Hibiscus seed oil biodiesel (H05) and test was conducted with the blend of 95% diesel and 05% biodiesel by varying 0 to 100% of load on the engine with an increment of 20%. After the Hibiscus seed oil biodiesel, the test was conducted with the blend of 85% diesel and 15% biodiesel (H15).

After the Hibiscus seed oil biodiesel, the test was conducted with the blend of 75% diesel and 25% biodiesel (H25) and after the Hibiscus seed oil biodiesel, the test was conducted with the blend of 65% diesel and 35% biodiesel (H35). The directly blended fuel does not require any modifications to diesel engines. Hence direct blending method was used in this test. The tests were conducted with these three blends by varying the load on the engine. The brake power was measured by using an electrical dynamometer. The mass of the fuel consumption was measured by using a fuel tank fitted with a burette and a stop watch. The brake thermal efficiency and brake specific fuel consumption were calculated from the observed values. The exhaust gas temperature was measured by using an iron-constantan thermocouple. The exhaust emissions such as carbon monoxide, carbon dioxide, nitrogen oxides, hydrocarbons and unused oxygen were measured by exhaust an analyser and the smoke opacity by smoke meter.

Fig: 3. 4- Stroke 1-C diesel engine

IV. RESULTS AND DISCUSSION

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying 0 to 100% loads with diesel and different blends of LSOEE like H05, H15, H25, H35, H15D84.5H0.5%, H15D84H1% and H15D83.5H1.5%.

The performance parameters such as brake thermal efficiency and brake specific fuel consumption were calculated from the observed parameters and shown in the graphs. The other emissions parameters such as exhaust gas emissions such as Carbon monoxide, hydrocarbons, and oxides of nitrogen, carbon dioxide, unused oxygen and smoke were represented in the form of graphs from the measured values. The variation of performance parameters and emissions are discussed with respect to the brake power for diesel fuel, diesel-biodiesel blends and obtained optimum blend with adding ignition-improver are discussed in below article.

A. *Brake Thermal Efficiency*

The maximum thermal efficiency for H15 at full load 33.77% was higher than that of diesel (32.16%). Increase in thermal efficiency due to the more percentage of oxygen presence in the biodiesel, the extra oxygen leads to causes better combustion inside the combustion chamber.

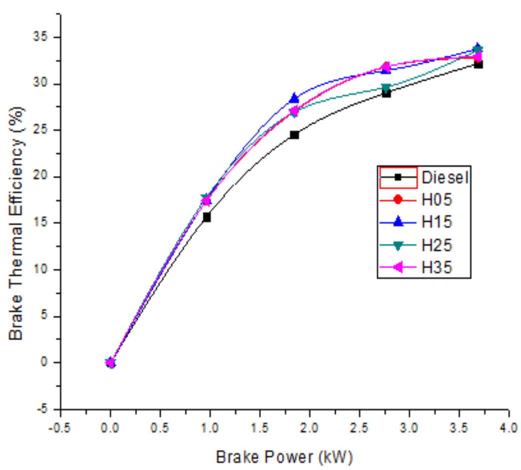

Fig.4 Variation of Brake Thermal Efficiency with Brake power using HOEE Blends

B. *Mechanical Efficiency*

It is observed diesel and its blends like H15 nearly equal at full load conditions. But considerable improvement in mechanical efficiency was observed by the blend H15 is 67.77% because of lowest frictional powers compared to diesel.

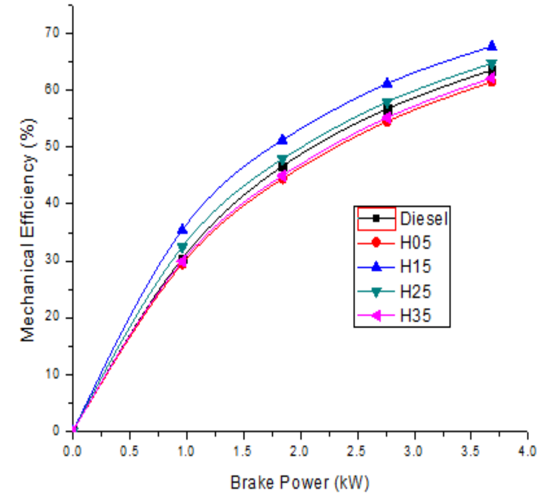

Fig.5. Variation of Mechanical Efficiency with Brake power using HOEE Blends

C. *Brake Specific Fuel Consumption*

It can be observed that the BSFC of 0.263kg/kW-hr were obtained for diesel and 0.252kg/kW-hr H15 at full load. It was observed that BSFC decreased with the increase in concentration of HOEE in diesel. The BSFC of Bio-diesel is decreases up to 4.56% as compared with diesel at full load condition.

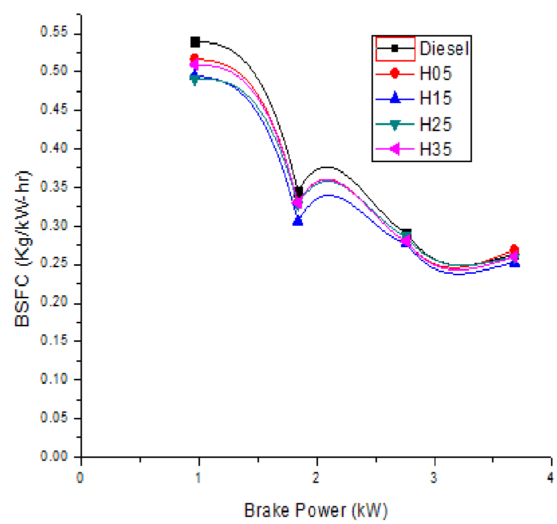

Fig.6. Variation of Brake specific fuel consumption with Brake Power using HOEE Blends

D. *Volumetric Efficiency*

It has been observed that there is no change in volumetric efficiency with the increase in Break power in diesel fuel at all loads. However the volumetric efficiency decreases at high loads in the case H05, H15, H25 and H35. It is observed diesel contains 80.87% at full load, in case of H15 at full load 79.34%.therfore the decrease in volumetric efficiency 1.53% while using H15.

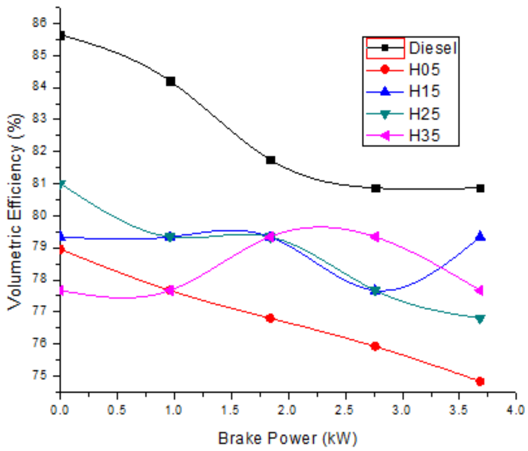

Fig.7. Variation of Volumetric Efficiency with Brake power using HOEE Blends

E. Carbon Monoxide (CO)

For HOEE carbon monoxide emission level is lower than that of diesel, 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.

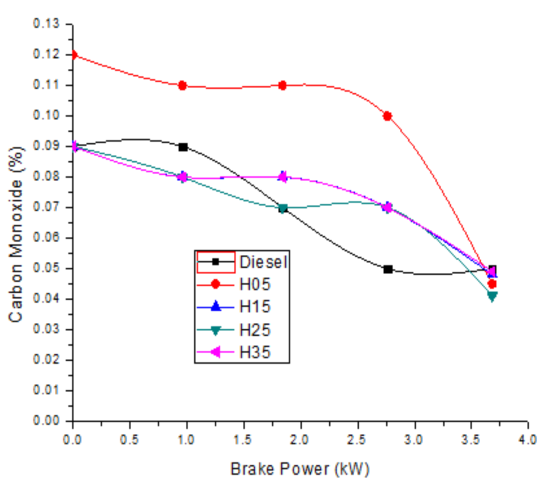

Fig.8. Variation of Carbon monoxide emissions with Brake power using HOEE Blends

F. Carbon Dioxide (CO2)

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 H15 it is 6.40 %. The increase in CO_2 emissions is 6.66%.

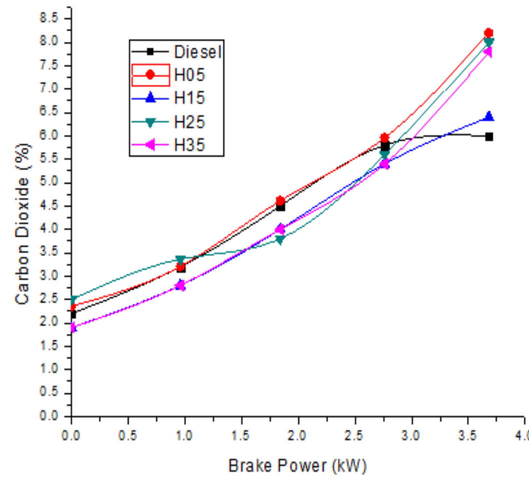

Fig.9. Variation of Carbon Dioxide with Brake power using HOEE Blends

G. Hydrocarbons Emissions (HC)

At full load diesel contains 58 ppm where as in case of H15 it is 36 ppm at same load. So there is a reduction from 58 ppm to 36 ppm at full load these reductions indicate a more complete combustion of the fuel. The presence of oxygen in the fuel was thought to promote complete combustion.

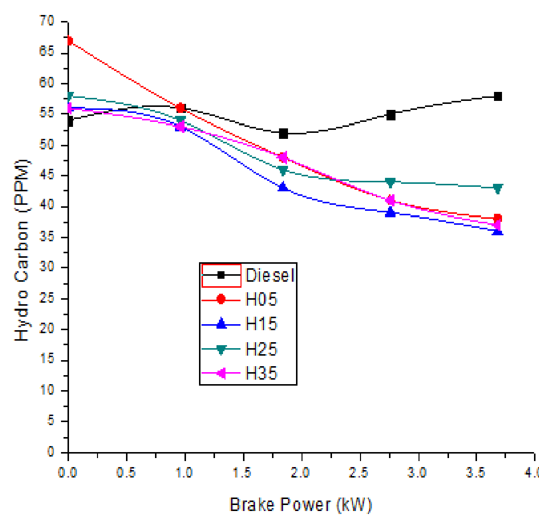

Fig.10. Variation Unburned hydrocarbons emissions with Brake power using HOEE Blends

V.CONCLUSION

- The maximum brake thermal efficiency for H15 (33.77%) is higher than that of diesel (32.16%).

The brake thermal efficiency increased in 4.76% compared with diesel.

- Brake specific fuel consumption is decreases in blended fuels. In H15 (0.252 kg/kW-hr) fuel the BSFC is lower than the diesel (0.263 kg/kW-hr) in 4.18%.
- The reductions in smoke level, CO emissions with H15 blend. Smoke level is decreased by 26.8% with H15 blend compared to diesel at maximum load. On the other hand, NOx emissions are decreased with H15 compared to diesel. NOx emissions are decreased by 15.65% with H15 compared diesel.
- The smoke density is reduced by 26.82% compared to the diesel.

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