PERFORMANCE ANALYSIS OF CI ENGINE USING WCO AS BIODIESEL

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Abstract

Due to increase in the utilization of Petroleum products and increase in the rate of petroleum fuel day to day is really creating problems for developing countries who are dependent on oversea suppliers and pay huge amount of import bill, It bring down our Economy. Other than the economy and development, use of fossil fuel also leads to a major problem like global warming and climate change. The emission of hazardous gasses like CO, NOx, CO_2, and HC (Hydrocarbons) causes acid rain, health hazard and also global warming. In the last few years interest & activity has grown up around the globe to find a substitute of fossil fuel. Biodiesel are the alternate fuels which are derived from the Animals fats & Plants seeds. Derived oil are in the form of Triglycerides and intern converted in to Simple Esters through the Tran-Esterification process. The main objective of this paper is to determine the properties of the biodiesel blends, comparing the performance characteristics of the Biodiesel blends at different loads. The testing results show without any modification to diesel engine and dynamic performance conditions kept usual. it has been shown that without any modification, these characteristics shows same nature of graph with reference to pure Diesel And at the higher loads B50 are found to be close comparison to diesel fuel.

Key Words: Biodiesel, Trans-Esterification, Waste Cooking Oil (WCO), Blends.

I. INTRODUCTION

In the initial period of 19th century the Dr. Rudolf diesel has carried out the biodiesel for the first time from the peanut oil and it was experimented for the compression Ignition (CI) Engine. But then, due availability of the crude oil, the demand is reduced for using biodiesel in the CI engine. In the present scenario, due to continues & limited supply of Petroleum products, prices are increasing day by day. Because of this reason, there is a need to find some alternate fuels for diesel in CI Engine.

So, many countries are paying attention for evaluation of the production. Waste vegetable oil methyl ester is a biodiesel, defined as widely recognized in the alternative fuel industry. Biodiesel is typically produced through the reaction of 1 mole vegetable oil or animal fat having the composition of Tri-glyceride with 3 moles methanol in the Sodium Hydroxide presence (NaOH) of a catalyst to yield glycerin and methyl esters [1,2]. Some attractive attractive features are (i) Biodiesel fuel is derived from seeds, which is not petroleum based, offers reduction in the emission of the CO_2 gasses causes "greenhouse", (ii) Biodiesel can be produced domestically, helps to reduce the certain extent of importing the petroleum products and helps to create some employable opportunities for rural locations by producing some biodiesel crops in location where the rain is less (iii) There is reduction in the emission level of particulates, carbon monoxide (CO), and Biodiesel cal also be produced from Waste Cooking Oil (WCO).

WCO is much less expensive than pure vegetable oil, is a promising alternative to vegetable oil for biodiesel production. Restaurant waste oils and rendered animal fats are less expensive than food-grade canola and soybean oil. Currently, all these waste oils are sold commercially as animal feed [6]. If these WCO is utilized by the domestic animals, then it could result in the return of destructive compounds back into the food chain through the animal meat. So, this WCO must be disposed of carefully or be used in a way that is not harmful to human beings.

The quantity of WCO generated per year by any country is huge. The disposal of WCO is problematic, Due to increase in the disposal this dreadful oil contaminate with water and causes some environmental issue. And most of the developed countries have set regulations to restrictions for the disposal of waste oil through the water drainage, intern these drainages linked to the higher stream of water (Lakes, Rivers & sea) [8]. So finally that is going to affect the aquatic life and also the human life, since there are already so many disposals is being fed in to these water resources through the industrial wastes. Hence, it is a need of take care by utilizing this WCO by using as alternate fuel in CI Engine. As compared with Diesel, due to high cost of biodiesel is a major obstruction to its commercialization. It has been predicted that almost 70%–85% of the total biodiesel production cost arises from the cost of raw material. Use of low-cost feedstock for this WCO should help make biodiesel more economical in the price status. Many more researches have been carried-out on biodiesel production, performance and emission testing in the last few decades. It has been noted that one of the important concentration to reduce its production cost, as the cost of biodiesel is still higher than its petro-diesel counterpart. This clears a best chance for the use of WCO as its production feedstock. Low-cost feedstock such as WCO should help make biodiesel competitive in cost as compared with petroleum diesel [9].

Because of these above advantages of the WCO as compared with other biodiesels produced from vegetables, since from last decades there are lots of work is going on using WCO as alternate fuel. All the performance parameters for blends of WCO and its blends were within the range, & there is marginal difference in the in the BTE,

BSFC & BSEC [12]. And As far as Emission parameters are concerned, when blends biodiesel is included in to pure diesel dissolved oxygen contents present in the blends. Thus fuel is readily undergoes combustion process, due to less oxygen is needed for combustion. And traces of oxygen contents in the fuel is the main reason for more complete combustion and hence CO and HC emission reduction [1, 3]. But there is a slight increase in NOx (NO_2, NO_3 mainly) emissions, is due to delay in the combustion of the fuel, and Power is developed in the later stage of cycle, which increases higher temperature of the combustion products results increase in the emission of NOx [3,4]. The emission of sulfur is also, one of the main drawbacks in using IC Engines; they react in the atmosphere to form acids and causes chances of Acid rain, and disturbances in the pH range of Water causes unfavorable condition to Human & aquatic life. The biodiesel sulfur content is another favored advantage of the produced fuel which is 18 ppm only. As compared with biodiesel with the 25 times of sulfur content is available in pure diesel fuel, the advantage of the biodiesel over the diesel fuel in terms of the environmental benefits can be reasonable. This comparison indicates that the sulfur content of biodiesel produced from the waste vegetable oil in gives lesser emissions in terms of Sulfur emissions [1, 13]. one cannot use WCO directly in diesel engines as it has higher viscosity, free fatty acids content (FFA) and traces moisture with less volatile nature leading to severe engine deposits, injector choking and piston ring jamming/sticking [14]. These undesirable effects can be removed by the process called transesterification.

II. TRANSESTERIFICATION

The oil extracted from the seeds is not favorable to use as a biodiesel. This is because of the high flash point, less Volatility & more viscous in nature. So in order to achieve the properties near to pure diesel, the Tri-Glyceride of the WCO is converted in to Simple Ester form which is byproduct as Glycerol. This product formation of simple ester is known as Biodiesel, and this biodiesel is simple liquid fuel derived from the vegetables oils and fat from the animals.

And the oil has similar properties as compared to the pure diesel. So, the biodiesel is an alternative fuel to pure diesel. The reaction is carried out in order to convert the oil into the WCO biodiesel is known as trans-esterification.

It is very important to have ratio of the oil & alcohol, the stoichiometry (Theoretical) of the trans-esterification reaction requires 3 moles of methanol to react with single mole of triglyceride in order to form 3 moles of simple ester & a mol of glycerol. To shift the trans-esterification process towards the end as early as possible, there is need of either a substantial abundance of methanol or to expel one of the products from the reaction process. Extra methanol is generally utilized for complete transition of the fats or seed-oil to its esters form. Furthur the, following steps performed to produce biodiesel.

- Step-1: WCO is heated first in a flask for about 60 minutes up to 60°C so that there will not be any moisture content left in the oil. The oil is stirred during this period at 600 rpm continuously.
- Step-2. In the meantime, during preheating of WCO, methoxide solution is prepared by adding 5g of Sodium Hydroxide (NaOH catalyst) in 250 ml methanol in a conical flask.
- Step-3 . Add methoxide solution to batch of warm oil and maintained the stirring speed at 600 rpm to ensure proper transesterification process. The temperature is maintained at 60°C for almost 50 minutes.
- Step-4 . Then the mixture is poured in a separating funnel and left for settlement of glycerol and biodiesel. The settling of layers takes place in about 6-8 hours. Since glycerol is heavier, it settles in lower side which is to be tapped out and then there will be only biodiesel left in the separating funnel which is impure. This impure biodiesel has to be washed before storage.
- Step-5. Three times washing of biodiesel with distilled water is done so that there will not be any soap content or physical impurity. Finally biodiesel is heated in a round bottom flask for 30-40 minutes at 50°C for removing any moisture content from it. Now biodiesel is in pure form and is then stored in an air-tight container away from sunlight to avoid any thermal and chemical degradation.

III. DETERMINING THE PROPERTIES OF THE FUEL

In the Preparation of Biodiesel, different blends of the biodiesel with pure diesel fuel have been prepared. Blends of biodiesel based diesel are produced by mixing biodiesel and diesel in suitable proportions under appropriate conditions. Commonly, the present system known as the "B" element to define the percentage of biodiesel in any fuel mixture in Diesel fuel.

A. Calorific value

Calorific value of the fuel is measured by using Bomb calorimeter. Approximately 1 gm of a given fuel sample is taken into a pellet. The pellet is weighed accurately and placed in the crucible. Sufficient length of cotton thread and fuse wire are weighed carefully. One end of the cotton thread is kept in contact with the pellet and the other end is attached to the fuse wire. The fuse wire is attached to the leads and electric ignition system circuit is completed. The bomb is assembled and filled with oxygen. The calorimeter vessel is filled with water and thermometer is inserted. Initial reading of thermometer is noted and the fire button is pressed to ignite the fuel. Then the temperature readings of the water are taken down till it reaches a maximum value.

Further, the Fig: 1, the blends of biodiesel vs. calorific value, It is seen from the fig.6 that the Calorific Value decreased by increase in the ratio of the WCO blends, the reason is due to the presence of the Un-saturated (Alkenes & Alkynes structure) Hydro-Carbon & Oxygen Residue is going to increase by increasing the Blend percentage [17].

B.Density

Kinematic viscosity of the fuel is measured by using Redwood viscometer. The viscosity of the oil to be measured is poured in to a cup surrounded by water Jacket. The thermometer is clamped in position.

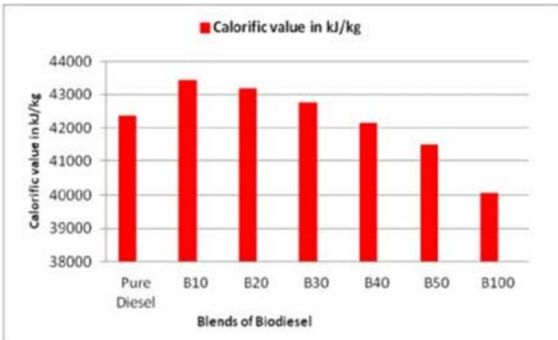

Fig: 1 Blends of Biodiesel vs. Calorific value in kJ/kg

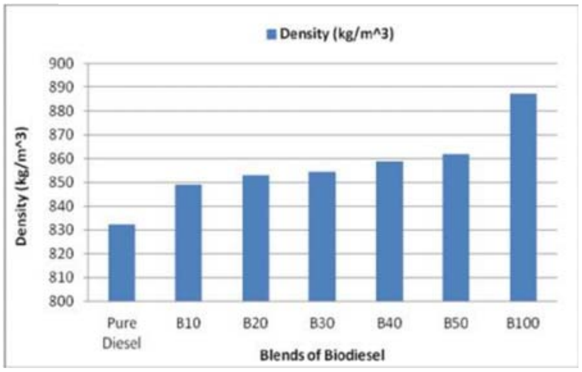

Fig: 2 Biodiesel blends vs. Density (kg/m3)

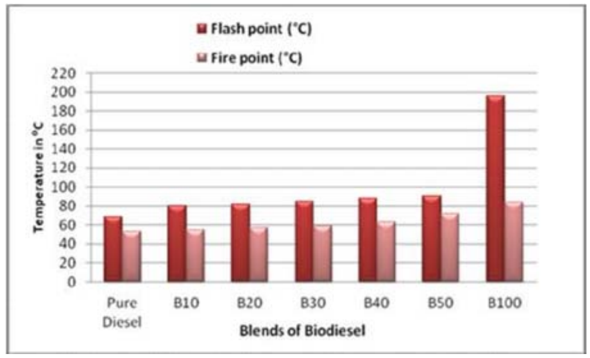

Fig: 3 Flash & Fire Point of the Biodiesel blends

Weight of empty 50ml measuring flask is noted. The heater is switched on and temperature of oil in the cup is monitored. When the oil reaches the temperature at which viscosity is to be determined, heating is stopped. 50ml measuring flask is placed below the jet. The ball valve is lifted and simultaneously the stop watch is started. The stop watch is stopped and ball valve is closed when the oil in the flask crosses the 50ml mark. Then weight of the flask with 50ml of oil is noted. Dynamic Viscosity is directly proportional to the Density of the fuel and Density varies for the various blends of fuel as shown in below Fig: 2. The density of the biodiesel is found out to be more in the WCO biodiesel blends as compared to the pure diesel, due to more Free Fatty acids (FFA) content in the biodiesel. For Pure Diesel, B10, B20, B30, B40, B50 & B100 fall with-in the range but B100 is having bit higher value. That is increase in the ratio of WCO biodiesel blend, increases density of the fuel. This is because of the Biodiesel is more viscous in nature compared to the Pure Diesel.

C. Flash point and fire Point:

The cup is filled with the fuel sample up to the mark. The cup is heated electrically. The rise of temperature is controlled by regulator and rise on thermometer is constantly watched. Test flame is lighted. The test flame is first applied at a temperature about 100°C. Test for the flash point is carried at every 5°C to 10°C rise. The temperature at which the liquid catches fire is gives the flash point of the fuel. Fire point is estimated by continuing heating further at the same rate. Note down the temperature at which air vapour mixture gets ignited and continue to burn for at least five seconds when the test flame is brought near to it. It is found that as the percentage of the Biodiesel increases the Burning of the Fuel occurs at higher temperature i.e., The Flash & Fire point is going to increase as shown in Fig: 3, this is due to the fact that, viscous nature of the fuel & presence of the Un-Saturated Hydro Carbon bonds exist in the biodiesel with more probability.

IV. ENGINE SETUP

The experiments are conducted on direct injection, single cylinder four stroke Kirloskar diesel engines. The layout of experimental test rig and its instrumentation is shown in Fig: 4 & specification is given in the Table 1 injection time. It consists of a test bed, a diesel engine with a rope brakedrum dynamometer eddy. The engine is connected to rope drum dynamometer. The rope drum dynamometer is mounted on base frame and connected to engine. The engine is subjected to different loads with the help of dynamometer. Temperature sensors are fitted at the inlet and outlet of the calorimeter for temperature measurement. The pump is provided for supplying water to rope drum dynamometer, engine cooling and calorimeter. An orifice meter with manometer is fitted at the inlet of air box for flow measurement. Thermocouple type temperature sensors measure cooling water inlet, outlet and exhaust temperatures. A fixed 220 bar injection pressure, normal injection timing 23˚bTDC and 17.5 compression ratio are used throughout the experiments. Indicators on the test bed show the following quantities which are measured electrically: engine speed, brake power and various temperatures. The engine is tested at constant rated speed of 1500 rpm throughout its power range using B0, B10, B20, B30, B40, B60 and B80 blends. Speed of the engine can be measured by tachometer

In diesel engine, diesel is used as pilot fuel and then WCO blends are used as main fuel. For each blend all the engine performance characteristics are noted and examined. For each testing of blends fuel is completely removed from tank, then new WCO blend is added as the fuel and engine performance are tested.

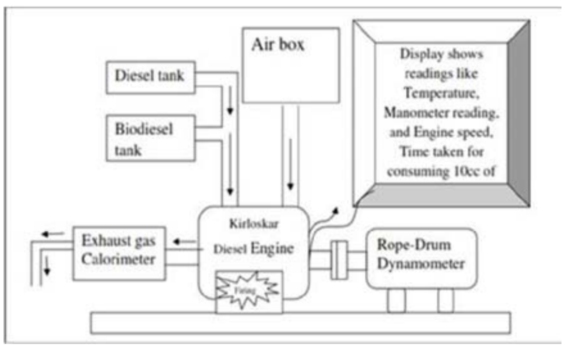

Fig: 4 Layout of the experimental setup

Table 1: Engine specifications

Make	Kirloskar Diesel Engine
Bore & stroke	87.5 mmx110mm
Type of cooling	Water cooled
Speed	1500 rpm
Compression ratio	17.5:1
Number of cylinder	1
Rated power	5.2kW
Start of injection	23˚ bTDC
Injection pressure	220 bar

V. RESULTS AND DISCUSSION

Using various blends of biodiesel and diesel the CI engine is tested at constant speed, varying the load up to the rated load keeping cooling water flow and calorimeter water flow constant to evaluate various performance parameters. In this testing of engine using conventional diesel and biodiesel blends is carrying with varying load from 0 kg to 20kg and the readings are noted down.

A. *Brake thermal efficiency*

The variations of the Brake Thermal Efficiency (BTE) with load for blends is shown in Fig: 5; BTE of an engine is defined as the ratio of the brake power output to that of the chemical energy input in the form of fuel supply. It is the true indication with which the thermodynamic input is converted into mechanical work. For all blends tested, BTE increases with increase in load. The BTE for B10, B20, B30, B40, B60 and B80 is lesser than that of diesel at 15 kg of load. This drop in BTE is attributed to poor atomization of the blends due to viscosity, density and lower Calorific value of the fuel.

B. *Brake specific fuel consumption*

The variations of Brake specific fuel consumption (BSFC) with load for WCO blends are shown in Fig: 6. BSFC is defined as the amount of fuel consumed per unit of brake output of the engine. It is observed that for all the the fuels tested, BSFC decreases with increase in load. As the BSFC is calculated on weight basis, obviously higher densities resulted in higher values for BSFC. As density of WCO biodiesel is higher than that of diesel, for the same fuel consumption on volume basis, B80 biodiesel yield higher BSFC. The higher densities of biodiesel blend caused higher mass of injection for the same volume at the same injection pressure. The calorific value of biodiesel is less than diesel, due to these reasons the BSFC for other blends are higher than that of diesel. The BSFC of B30 is best amongst all blends because difference is not more than 1% and also nearly matches to that of diesel.

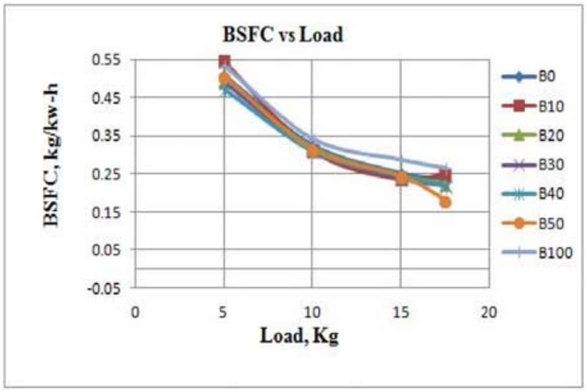

Fig: 5: Variation of brake thermal efficiency vs. load

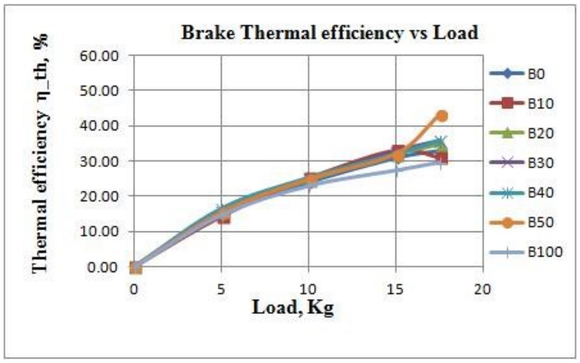

Fig: 6 Variation of BSFC vs. load

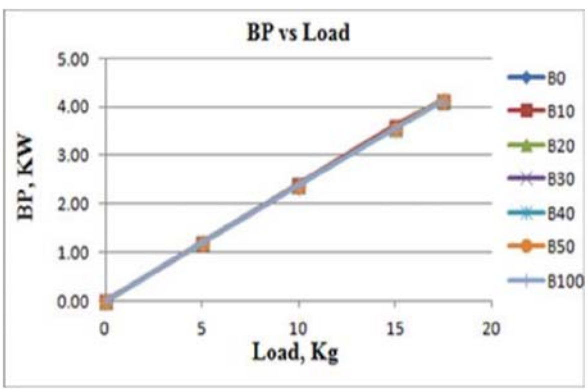

Fig: 7 Variation of Brake Power vs. Load

C. Brake power

Brake power is the actual or useful power of an engine usually determined from the force exerted on a friction brake or dynamometer connected to the drive shaft. The variation of brake power with respect to load is shown in the Fig: 7.

D.Mech efficiency

The variation of the mechanical efficiency with load for WCO blends is shown in Fig: 8. Mechanical efficiency is defined as the ratio of BP to IP. It is observed that mechanical efficiency is similar for all blends. Even the Brake thermal Efficiency is less, but the Mechanical Efficiency is almost same for all the blends of the biodiesel at all the loads, it is because of lubrication effect provided by the WCO biodiesels.

E. Air fuel ratio

The variation of the air fuel ratio with load for diesel and WCO blends are shown in Fig: 9. Air fuel ratio is the ratio of mass of air to the mass of fuel. In CI engine as air-fuel ratio decreases, increases the power output of the engine. The air-fuel mixing process is affected by the atomization of biodiesel due to higher viscosity, maximum temperature and the completeness of combustion. The fuel undergoes the complete combustion process, at the later stage of the Power stroke for the biodiesel blends (delay in combustion period) [15].

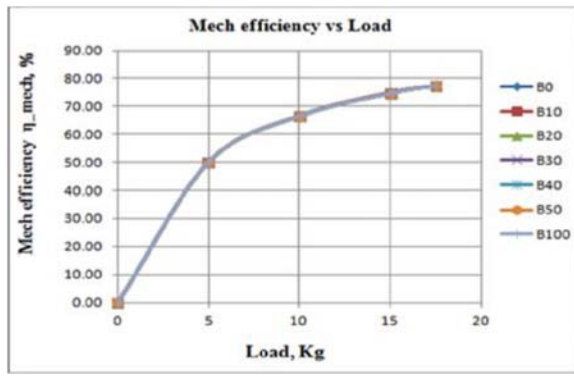

Fig: 8 Variation of Mechanical Efficiency vs. Load

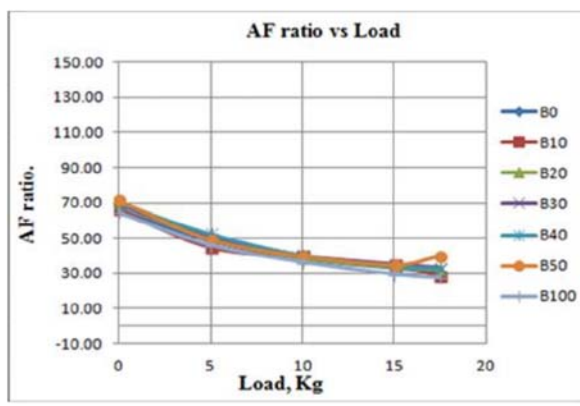

Fig: 9 Variation of air fuel ratio vs. load

VI. CONCLUSIONS & SCOPE FOR FUTURE WORK

The present study is carried out in order to compare the performance of a diesel engine fuelled with mineral diesel and biodiesel WCO blends. In this paper, the experimental work on a single cylinder four stroke Diesel Engine using biodiesel WCO (WCO) is used as an alternate fuel. The conclusions are drawn from the present work is given below:

- The yield of biodiesel mainly depends on few factors such as oil to alcohol molar ratio, reaction time, reaction temperature, quantity of catalyst. Optimum value of these factors is found as 6:1 molar ratio, 50 minutes reaction time, 60°C temperature and 5g of catalyst
- The properties of biodiesel are found very similar to that of mineral diesel.
- Performance characteristics BTE, BSFC, Mechanical Eff. & Volumetric Efficiency different blends WCO biodiesel are compared at different loads, it has been shown that without any modification, these characteristics shows same nature of graph with reference to pure Diesel and at the higher loads B50 are found to be close comparison to diesel fuel.

VII. ACKNOWLEDGEMENT

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