THE PERFORMANCE AND EXHAUST EMISSION ANALYSIS OF DIESEL ENGINE USING WASTE COOKING OIL

Jagadeesh S Bali[1], Channamallikarjun Sankanna[2]

[1]*Assistant Professor, Mechanical Department, PGMCOE, Wagholi, Pune, Maharastra, India*
bali.jagadeesh@gmail.com, Mob No- 9620910739
[2]*Assistant Professor, Mechanical Department, PGMCOE, Wagholi, Pune, Maharastra, India*
channamallikarjun.s@gmail.com

Abstract

From last ten year there has been number of increase in vehicles and corresponding to increase in the fuel price. For this reason the scientist will move towards alternative fuels like vegetable oils, biodiesel, etc. Biodiesel is one of the substitute fuels which is obtained from vegetable oils, Waste cooking oil. In this experiment, the biodiesel is produced from waste cooking oil using transisterification process, the present work has focused mainly on the performance and exhaust emission of waste cooking oil and its blend with diesel on diesel engine and its suitability is examined. The oil blended with diesel in proportion of 25/75%, 50/50%, 75/25%, and 100/100% on quantity basis after that biodiesel is analyzed. The performance and exhaust emission of blend are check out at a variable loads (brake power) of 0 1,2,3,4 at constant speed of 1500rpm and 5kW and results are compared. The experimental results show that there is mixing of lower percent of biodiesel in diesel give good results means increase mechanical efficiency, the brake thermal efficiency, and BSFC are well comparable with diesel. At full load CO, CO_2, and HC are lower compare to diesel. Hence we can use the biodiesel which produced from waste cooking oil can be an alternative fuel in a diesel engine. And also up to B25 there is no modification of our engine.

Keywords: *Trasisterification Process, Engine Performance, Exhaust Emissions, Fossil Fuel, Biodiesel, Alternative Fuels.*

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1. INTRODUCTION

The India which mainly depends on fossil fuels which are imported from other countries due to lack of fossil fuel reserves in india[1]. And also The Use of diesel in engines could lead to a lot of knocking in the engine [2]. This can cause damage to the engine. Diesel engines are produce gases such as carbon monoxide, un-burnt hydrocarbons and oxides of nitrogen which are harmful to human being. Due to hike in petroleum fuels and diesel engines emits more emission to environment for this the vegetables oils are used as an alternative fuels for engines. This vegetable oil as fuel in diesel engine was first used by Rudolf Diesel. The vegetable oil was more expensive than petroleum fuels due to this it could not get acceptance [3]. Later several researchers to use vegetable oils like coconut oil, sunflower oil, palm oil etc in diesel engine as fuel. These vegetable oils are suitable for eating in nature so if we use continuously they become shortage so later researchers are using non suitable for eating oils like jatropha, mahuva oil as fuel. The vegetable oils have high viscosity compare to diesel fuel [4].The higher viscosity leads to incomplete combustion [5].The Viscosity can be solved by following methods like blending with diesel fuel, preheating, micro Emulsification with diesel ethanol or methanol, and trasisterification process i.e. converting them into biodiesel fuels.[6] For improving their performance and emissions,[7]. Bio diesel is methyl ester of fatty acid made from waste cooking oil and vegetable oils [8]. The production and use of biodiesel has increased significantly in all over world. In India, much waste cooking oil is produced by a number of local restaurants such as Spur, McDonald's, Dros, and Fast Food Chain etc. Management of such oils and fats poses a major challenge because of their dumping problems [9].The most of the used cooking oil is poured into the sewer of cities. This may leads to the pollution of rivers, lakes, and seas etc. which is very harmful to the environment and human health [9].This problem can be solved by utilizing some of this waste cooking oil to produce cleaner Biodiesel. For this reason the waste cooking oil is efficiently and economically used [10]. From above stated factors it is evident that the waste cooking oil on diesel engine is of great importance, the investigation is focused on waste cooking oil suitability in Diesel engine [11].

2. MATERIAL & METHODS

2.1 Material

The meaning for "waste cooking oil" (WCO) is oil vegetable oil and which is a waste oil produced from cooking. It has no longer viable for its intended use. The sample for this oil is palm oil because it is commonly used oil in the restaurants and hostel kitchens [12]. Used cooking oil is normally black, a strong odor.

2.2 Methods for Making Biodiesel

The waste cooking oil (WCO) has different properties compare to fresh cooking oils. It has more content of FFA level, high viscosity and density. Due to its high viscosity, the oil needs to be chemically modified into esters whose properties resemble those of fossil fuels. These chemically modified processes are called trasisterification[13,14,and15].

Triglycerides +alcohol ⇨ ester+ by product
(Catalyst)

Transesterification Procedeure

The figure 1 shows transisterification process and it consists of four steps as follows:

- ❖ Add the catalyst to neutralize the free fatty acids
- ❖ Preparation of methoxide solution
- ❖ Formation of biodiesel and glycerol
- ❖ Clean the obtained bio-diesel

STEP: 1: In this step, find out the amount of catalyst required to neutralize the free fatty acids. This can be done by titration process. First prepare the stock solution by adding 1gm of KOH in a perfect measured one liter of distilled water. Then this value becomes 1gm/1000ml or 0.001 alkali. Fill the stock solution in 25ml burette. Then take 1 ml of oil using pipette and dilute this in 10 ml of isopropyl alcohol. Add two drops of phenapthelene colour indicator and keep it closed. Then start the titration process. Then the colour of the oil changes into pink colour. Then watch the burette how much ml is consumed. If suppose it is consumed by 5 ml, then there is a 5% of free fatty acids and we require 20 gm of catalyst to neutralize fatty acids. In this our oil has 1% of FFA. Thus it requires 5gm of KOH with 200 ml of methanol.

STEP: 2: Prepare the methoxide solution by mixing of methanol with potassium hydroxide. Mix the 5gm of KOH with 200 ml of methanol and keep it safely.

Fig 1: Three necked flask on magnetic stirrer

STEP 3: Take the one liter of oil, heat the oil up to 65^0 C and react with methoxide solution fastly by using a glass rod. Then pour the oil in a separate vessel and allow sufficient time for separation of bio-diesel and glycerol.After some time, we find two layers which are maximum at top and minimum at bottom. The top layer is called bio-diesel or methyl ester and the bottom layer is a byproduct called glycerol.

STEP 4: Clean the oil with the distilled water for two or three times. First clean the oil with distilled water to remove the untreated methoxide and then heat the oil to remove any water traces and finally we obtain a clear bio-diesel.

3. THE EXPERIMENTAL SET UP

Table1: Engine Specifications

Name of the engine: AV1 KIRLOSKAR OIL ENGINES
Engine : single cylinder, Diesel engine, four stroke
Number of cylinders: 1
Bore: 87.5mm
Stroke : 110mm
Rated power: 5.2kW
Injection pressure : 190 bar
Injection timing : 23 deg TDC
Type of sensor : piezo electric
Rated speed : 1500rpm constant
Compression ratio : 16.5:1

This investigation was conducted above mentioned diesel engine. The Engine was directly coupled to Eddy current dynamometer. The engine and dynamometer was connected to a computer. The computer records the parameters like fuel flow rate, temperatures, air flow rate, load etc. and by using this it calculates the brakes specific fuel consumption, brake thermal efficiency, Volumetric efficiency etc., The density and calorific value of a particular fuel was entered into the software. The exhaust emission is calculated by using gas analyzer.

Figure2: Experimental set up of computerized C.I. Engine

3.1 Experimental Procedure

The engine was run at a constant rated speed of 1500 rpm and variable load (brake power) of 0, 1, 2, 3, 4, at 5 kW of 190bar injection pressure. Before taking all readings the engine is warmed up. Now prepare for different blends of biodiesel from waste cooking oil with diesel namely B25, B50, B75, and B100.

4 RESULTS AND DISCUSSION

4.1 Fuel Properties

Bomb calorimeter is used to find calorific values of the biodiesel. The biodiesel calorific values are low compare to diesel, the reason for the lower value is because of oxygen present in vegetable oils which lowers their calorific values. The viscosity can be determined by using saybolt viscometer apparatus. The WCO contains high viscosity it is reduced by transiserification process. The flash point is determined by the Pensky-Marten apparatus.

Table2: Properties of Standard Diesel and Biodiesel

Property	WCO	Biodiesel	Diesel
Kinematic Viscosity At 40°C (mm^2/s)	39.7	6.58	2.4
Calorific Value (MJ/kg)	36.13	35.64	42.5
Cloud Point (°C)	0	2	-5
Pour Point (°C)	-40.7	-8	-20
Flash Point (°C)	278	180	75
Density (kg/m^3) At 15°C	910	885	840

Table 3: Density and Calorific Value of Different Fuel Blends

Sl. No	Blend of fuel	Density (Kg/m^3)	Calorific value (KJ/Kg)
1	B0	840	42500
2	B25	853	40785
3	B50	866	39070
4	B75	879	37355
5	B100	885	35640

4.2 Engine Performance

Brake Power Vs Fuel Consumption

This figure shows the fuel consumption increases corresponding to increase of brake power. The fuel consumption depends up on the calorific value of the fuels. With increase in the calorific value the fuel consumption reduces. The diesel fuel has more calorific value compared with the fuel blends. So the fuel consumption of the blends are higher than the diesel fuel due to lower calorific value of the fuel blends (B25, B50, B75 and B100).the fuel consumption for diesel is 33.5(kg/h), whereas B25 is 34.7(kg/h), is higher by 1.2(kg/h) and we can say that fuel consumption of B25 is well compare For B50, B75 and B100, corresponding fuel consumption is 49.6, 52.6, and 54.7(kg/h).

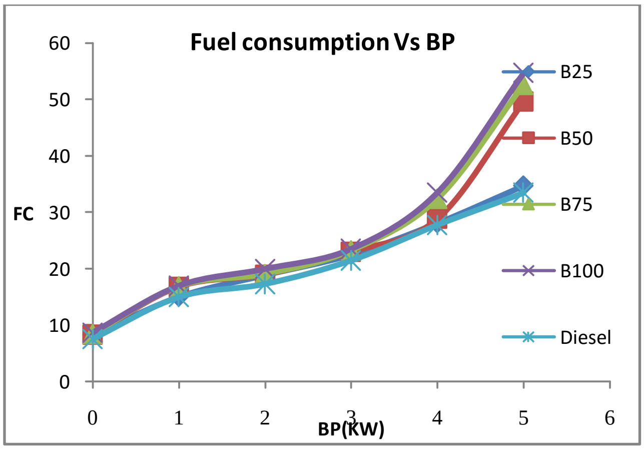

Figure: 3 fuel consumption vs. BP

Brake Power Vs Specific Fuel Consumption

The graph shows that with increase in brake power the specific fuel consumptions are reduces. The specific fuel consumption of the Bio diesel blends are more than the diesel fuel. But the B25 and B50 fuel blends specific fuel consumption are nearer to the diesel fuel. The SFC of B25 is 0.465(kg/kW-h) against diesel is 0.438(kg/kW-h) is higher by 0.027(kg/kW-h). We can say that fuel consumption of B25 is well comparable.

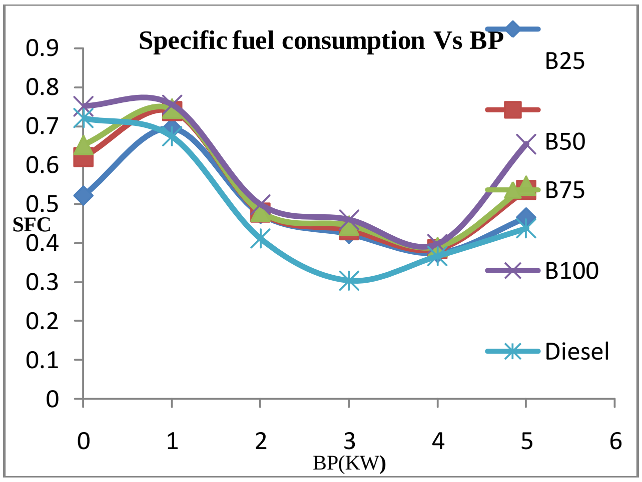

Figure: 4 SFC vs. BP

Brake Power Vs Brake Thermal Efficiency

The figure shows the brake thermal efficiency of B100 is more compare to diesel oil. The maximum brake thermal efficiency of B100 is 28.9%, against 21.5% of diesel oil which is lower by 7.4%. B25 BTE is 23.9% which is almost near to diesel, so we can say that B25 is comparable with diesel fuel.

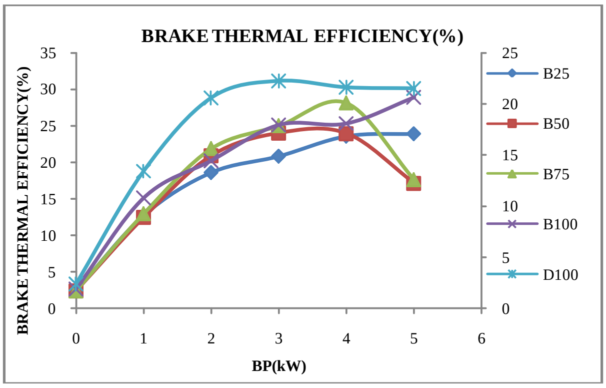

Figure 5: brake thermal efficiency vs. BP

Brake Power Vs Mechanical Efficiency (%)

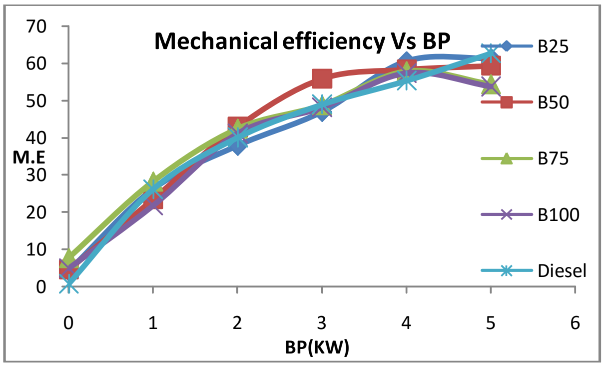

Figure 6: mechanical efficiency vs. BP

The figure shows clearly that the mechanical efficiency for D100% is similar to waste cooking oil blends. This is because of low viscosity, higher cetane number. The maximum mechanical efficiency for diesel oil is 62.71% and maximum mechanical efficiency for 100% blend is 65.92%. Similarly other blends maximum mechanical efficiency is 62.45, 63.09, and 62.31 for B25, B50, and B75% respectively.

4.3 Emission Characteristics

Brake Power Vs CO_2

The addition of the biodiesel to the blend decreased the CO2 emissions. This graph shows the carbon dioxide emission increases corresponding to increase in the brake power. At low load condition the carbon dioxide emission of diesel fuel is higher than blended fuels. This may be because of the vegetable oil containing oxygen elements. Increasing percentage of biodiesel in the blend, decrease the emission of CO2. For B25 and B50 biodiesel the emission is less than diesel. Biodiesel has higher cetane number compared standard diesel.

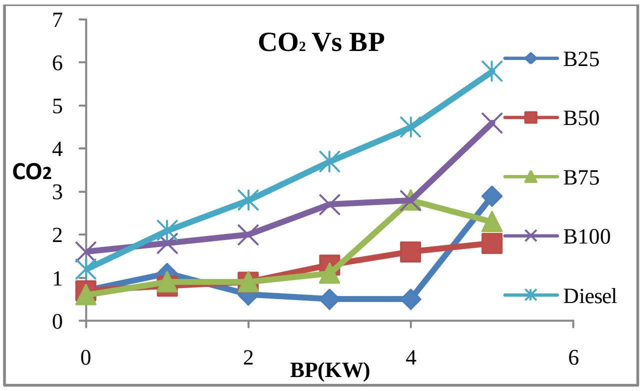

Figure 7: CO_2 vs. BP

Brake Power Vs Co

The figure clearly shows that the carbon monoxide emissions are increasing corresponding to increase in the brake power. The carbon monoxide emission variations are due to the incomplete combustion in the combustion chamber. At full load condition, the carbon monoxide emission of the fuel blend B100 and B50 is higher than the diesel fuel. But B25, B75 are nearer to diesel. This is because of incomplete combustion in combustion.

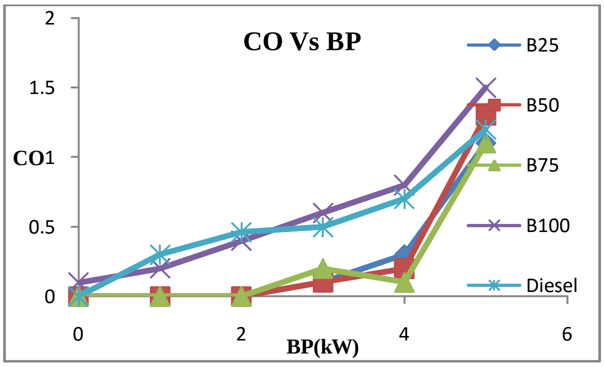

Figure 8: CO vs. BP

Brake Power Vs HC

The figure shows that the hydrocarbon emissions of the waste cooking oil for different blends are lesser than the diesel fuel at full load conditions. The B100 has the lowest hydrocarbon emission than the other fuels. The maximum hydrocarbon emission for diesel fuel is 230ppm.

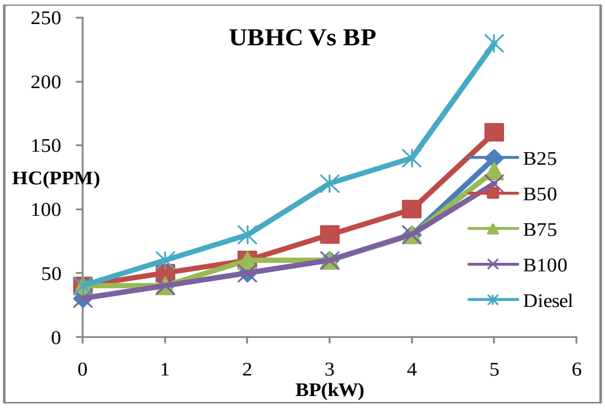

Figure 9: UBHC vs. BP

5. CONCLUSIONS

1. In this study it examined that the suitability of waste cooking oil as an alternative fuel. The results shows that, the properties of density, viscosity, flash point, and fire point of waste cooking oil are higher and calorific values lower than diesel.
2. The fuel consumption of the waste cooking oil blends is higher than the diesel fuel. The fuel consumption for diesel is 33.5(kg/h), whereas B25 is 34.7(kg/h), is higher by 1.2(kg/h).
3. The specific fuel consumption of the waste cooking oil blends are more than the diesel fuel. The SFC of B25 is 0.465(kg/kW-h) against diesel is 0.438(kg/kW-h) is higher by 0.027(kg/kW-h).
4. The brake thermal efficiency for waste cooking oil for all blends is almost similar to efficiency of diesel fuel. The maximum brake thermal efficiency of B100 is 28.9%, against 21.5% of diesel oil which is higher by 7.4%. B25 BTE is 23.9% which is almost near to diesel.
5. The maximum mechanical efficiency for diesel oil is 62.71% and maximum mechanical efficiency for 100% blend is 65.92%.
6. There was a reduction in CO and CO_2 emission for Waste cooking oil blend at B25 at full load condition.
7. The hydrocarbon emissions of the blends (B25, B50) are lower than the diesel fuel at all full conditions. The maximum hydrocarbon emission for diesel fuel is 230ppm.
8. From above investigations we can say that the waste cooking oil is an alternative fuel for diesel engine and can be used as fuel for diesel engine without any alteration.

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BIOGRAPHIES

Prof.Jagadeesh Bali
Presently working in PGMCOE Pune, as Assistant Prof. and has 4 year teaching experience and published 04 International Journals.

Prof.Channamallikarjun Sankanna presently working in PGMCOE Pune, as Assistant Prof. and has 4 year Teaching experience.