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Preparation Of Biodiesel From Waste Cooking Oil And Studythe Effect On Performance Of Diesel Engine

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Abstract: The fuel prices are sky rocketing day by day and fossil fuel are at verge of depletion in coming few decades. Since our country is not self-dependent in energy source and every year huge amount is spent in fulfilling energy demands. So, we should focus on finding new alternative source of energy and government have taken initiatives and invested money in the research and development in the field of non conventional source of energy like solar, wind, biogas, biomass, biodiesel etc.

The project focuses on the production of biodiesel from waste cooking oil (which will obtained from restaurants, hotels etc.) also the production of biodiesel should be affordable and consumes less production cost as well as it should be ecofriendly Biodiesel is prepared from the trans-esterification process which involves two steps- acidic esterification in which oil, solution of sulphuric acid and methanol is heated and in second step, trans-esterification reaction is carried out. After completion of reaction it is kept for settling and glycerol is separated from biodiesel. The prepared biodiesel is then test for some important properties of fuel like calorific value, viscosity, and density.

Comparison of the optimum conditions of alkaline-catalyzed transesterification process for biodiesel production from pure sunflower cooking oil (PSCO) and waste sunflower cooking oil (WSCO) through transesterification process using alkaline catalysts. To obtain a high quality biodiesel fuel that comply the specification of standard methods (ASTM D 6751 & EN 14214), some important variables such as volumetric ratio, types of reactants and catalytic activities were selected. The highest approximately 99.5% biodiesel yield acquired under optimum conditions of 1:6 volumetric oil-to-methanol ratio, 1% KOH catalyst at 40ºC reaction temperature and 320 rpm stirring speed. Result showed that the biodiesel production from PSCO and WSCO exhibited no considerable differences. The research demonstrated that biodiesel obtained under optimum conditions from PSCO & WSCO was of good quality and could be used as a diesel fuel which considered as renewable energy and environmental recycling process from waste oil after frying. Biodiesel fuel is a logical alternative to diesel fuel since it is renewable, environmentally friendly, and economically advantageous. Biodiesel is superior to conventional diesel in terms of its sulphur content, aromatic content and flash point. It is essentially sulphur free and non-aromatic while conventional diesel can contain up to 500 ppm SO2 and 20–40 wt% aromatic compounds. These advantages could be a key solution to reduce the problem of urban pollution since transport sector is an important contributor of the total gas emissions. Amongst vehicle fuels, diesel is dominant for black smoke particulate together with SO2 emissions and contributes to a one third of the total transport generated greenhouse gas emissions [31]. According to Utlu and Kocak [42] , there was on average of a decrease of 14% for CO2, 17.1% for CO and 22.5% for smoke density when using biodiesel.

Keyword: Biodiesel, waste cooking oil, soya-bean oil, engine performance, emission parameters, efficiency, properties of biodiesel etc.

INTRODUCTION:

Energy use is the most fundamental requirement for human existence. A high percentage of the world's total energy output is generated from fossil fuels and it has been universally conceded that fossil fuels are finite. The world is no longer endowed with new sources of cheap fossil fuels and experts have warned about the depletion of the present sources in the near future. Furthermore, the threat of supply instabilities and increased public awareness on impacts of fossil fuel emissions on environment and their potential health hazards triggered governments around the world to impose restrictions on fossil fuel combustion emissions [1]. The disadvantages of fossil fuels for the environment, created an interest for alternative fuel sources. One of the most promising renewable sources is biomass [2]. Among the biomass sources, vegetable oils and animal fats have attracted much attention as a potential resource for production of an alternative fuel such as biodiesel for the replacement of the petroleum-based diesel fuel. The biodiesel is renewable, biodegradable, non-toxic and it also has a favorable combustion emission profile, producing much less carbon monoxide, sulphur dioxide and unburned hydrocarbons than petroleum based diesel [3]. The biodiesel fuel (fatty acid methyl esters), which is produced by methanolysis (transesterification) of triglycerides [4] obtained from vegetable oils like soybean oil, jatropha oil, rapeseed oil, palm oil, sunflower oil, corn oil, peanut oil, canola oil and cottonseed oil [5]. The high viscosity and poor volatility are the major limitations of vegetable oils for their utilization of fuel in diesel engines. Because high viscous vegetable oils deteriorate the atomization, evaporation and air-fuel mixture formation characteristics leading to improper combustion and higher smoke emission. Moreover this high viscosity generates operational problems like difficulty in engine starting, unreliable ignition and deterioration in thermal efficiency. Converting to biodiesel is one of the options to reduce the viscosity of vegetable oils. Apart from vegetable oils, biodiesel can also be produced from other sources like animal fat (beef tallow, lard), waste cooking oil, greases (trap grease, float grease) and algae [6]. Because of the high price of high-quality virgin oils, the cost of biodiesel from these resources is higher than that of petroleum-based diesel [7]. The increasing production of waste cooking oil (WCO) from household, restaurants and industrial sources is a growing problem in the world.

The production of biodiesel from waste cooking oil to partially substitute petroleum diesel is one of the measures for solving the twin problems of environment pollution and energy shortage. . Waste cooking oil is one of the economical sources for biodiesel production. In this repot trans-esterification method for preparation of biodiesel is discussed.

In this review article, we examine various sources of biodiesel, vegetable oil, sunflower oil and used oil (waste cooking oil), comparison between PSCO (pure sunflower cooking oil) and WSCO (waste sunflower cooking oil), engine performance and properties of biodiesel etc.

BIODIESEL:

Biodiesel (fatty acid methyl ester) is a nontoxic alternative fuel that is obtained from renewable sources. The word “Bio” relates to its being renewable and of biological origin while “diesel” relates to the application in diesel engines (Zhang et al., 2003). Biodiesel is advised for use as an alternative fuel for conventional petroleum-based diesel chiefly be-cause it is a renewable, domestic resource with an environmentally friendly emission profile and is readily biodegradable (Zhang et al., 2003). The amount of greenhouse gas emissions, generating energy from renewable resources is being possessed a high priority gradually to decrease both over-reliance on imported fossil fuels (Blanco-Canqui and Lal, 2007). The high viscosity and poor volatility are the major limitations of vegetable oils for their utilization s fuel in diesel engines. Because high viscous vegetable oils deteriorate the atomization, evaporation and air-fuel mixture formation characteristics leading to improper combustion and higher smoke emission. Moreover this high viscosity generates operational problems like difficulty in engine starting, unreliable ignition and deterioration in thermal efficiency. Converting to biodiesel is one of the options to reduce the viscosity of vegetable oils (Paugazhabadivu et al., 2005).

WASTE COOKING OIL:

Waste cooking oil with highly variable and uncontrolled quality is used for the production biodiesel. The main objectives of this project is to define the analytical methods useful to obtaining information on the quality of the waste cooking oils as raw materials for biodiesel as well as for the characterization of the biodiesel obtained from them. Waste cooking oil from restaurants and domestic fryer were analyzed before and after trans-esterification to tatty acid methyl ester (FAME). The base catalyzed trans-esterification method is normally applied for biodiesel production. However biodiesel produced from crude or refined oils is usually more expensive than petroleum based diesel fuel. The recent concerns over sustainability, environmental issues and raw materials costs have a wide variety of qualities. Thus waste cooking oil can be highly heterogeneous as compare to crude or refined oils. Waste oil collectors do not usually make any payment for the oil, but collection and cleaning costs are high. The quality of this material may be expected to vary between countries, depending on the vegetable oil used, and variations in cooking practices and waste oil storage and collection systems. Biodiesel has been produced from waste cooking oil in small plant in Austria for several years (Mittelbach, 1996). Preliminary trials have also been carried out by Teagasc in Ireland. While results have been generally satisfactory, more development and demonstration work is required if an industry is to be established.

METHODOLOGY:

a) Collection of waste cooking oil: Waste cooking oil is collected from various restaurants, hotels, chips shops etc.
b) Preheating of waste cooking oil and filtration: For the production of biodiesel 100ml of waste cooking oil is taken in a round bottom glass flask of 1 liter capacity with a tight fitting stopper. The flask is heated at 600C in a water bath, to remove the water moisture from waste cooking oil. The above heated oil is filtered through filter paper to remove the impurities and suspended particles from the oil.

Fig 1: Filtration Process

c) Acid esterification process: The filtered oil is then undergoes to a next process i.e. acidic esterification reaction. In this process the solution of methanol and sulphuric acid is prepared and then added to the filtered oil. The above mixture is then allowed to settle into the separating funnel for 8-10 hrs.

Fig 2: Mixture of methanol and catalyst

After settling two layers will be formed, the below layer contains small amounts of glycerol and other impurities which is to be separated from the above mixture. The above mixture is taken for further processing i.e. acidic trans-esterification reaction.

d) Acidic trans-esterification process:

In acidic trans-esterification reaction, the titration process is performed as per the standard titration. A titration is necessary if we are using waste cooking oil because the fatty acids contents are different in different samples of waste cooking oil. The titration will help us to determine how much extra catalyst is needed to neutralize the fatty acids in the waste cooking oil (The catalyst can either be sodium hydroxide (NaOH) or potassium hydroxide (KOH). Transesterification is the most widely used for the conversion process. A typical schematic representation of the process is depicted in Figure 1 (Felizardo et al., 2006).

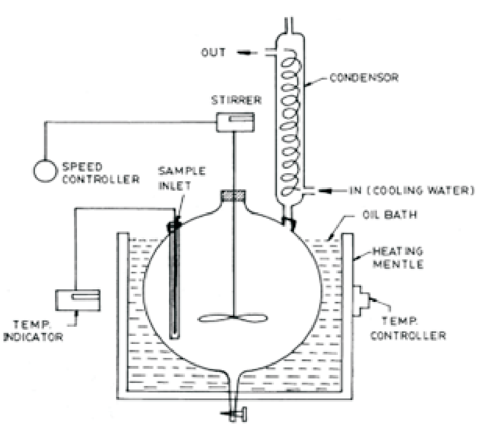

Fig 3: Schematic diagram of transesterification

The transesterification reaction performed at different volumetric ratio of oil to methanol, varying from 4:1, 3:1, 1:3, 1:4 and 1:6 at 40ºC and 350 rpm. The reaction time was kept constant at 3 hours for all experiments. Two types of catalysts have been used NaOH and KOH at a range of 0.5 -2.0% wt. of oil. After transesterification reaction the biodiesel wasseparated from glycerol using separating funnel and finally washed with 5% water followed by magnesium sulfate anhydrous to remove the water. Several basic variables, namely, catalyst type and concentration, methanol to oil ratio and reaction temperature of transesterification were investigated as they play a significant difference in biodiesel produced (Ma and Hanna, 1999).

Following are the acidic trans-esterification process, in this separating funnels is used to separate the mixture. The reaction solution separates into two obvious layers. The top layer is usually yellow or light brown color methyl ester. The layer is dark brown color and is mostly triglyceride with other minor components such as salts, soap etc. separate the different layers. The above layer is then used for further process.

Fig 4: Settling Process

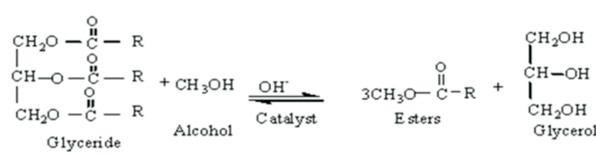

Fig 5: Reaction scheme of Trans-esterification Process

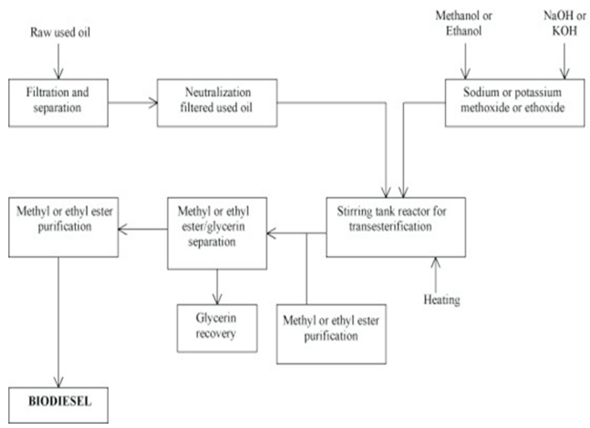

Fig 6: Flow Chart for preparation of biodiesel from waste cooking oil

a) Comparison of physicochemical properties of waste cooking oil with Diesel fuel:

The physicochemical properties of waste cooking oil such as density, viscosity, calorific value, flash point, fire point, cetane number etc., are going too compared with diesel fuel as per American Standard for Testing and Material (ASTM).

PROPERTIES OF BIO-DIESEL:

1) Density: Biodiesel is slightly heavier than conventional diesel fuel (sp. Gravity 0.88 compared to 0.84 for diesel oil). This allows the uses of splash blending by adding biodiesel on top of diesel fuel for making blends

2) Cetane number: Cetane number is indicative of its ignition characteristics. The higher is the cetane number, better is its ignition properties. The cetane number affects a number of engine performance parameters like combustion, stability, drivability, white smoke, noise, emission of HC and CO. Biodiesel has higher cetane number than conventional diesel fuel. This results in higher combustion efficiency and smoother combustion.

3) Viscosity: In addition to lubrication of fuel injection system components, fuel viscosity, control the characteristics of the injection from the diesel injector. The viscosity of biodiesel can reach very high level and hence it is important to control it within an acceptable level to avoid negative impact on the performance of the fuel injection system. Therefore the viscosity specification proposed is the same as that of the diesel.

4) Flash Point: The flash point of fuel is defined as the temperature at which it ignite when exposed to a flame or spark. The flash point of biodiesel is higher than the petroleum product. Thus in storage, biodiesel and its blend is safer than conventional diesel.

5) Cloud Point: Cloud point is the temperature at which a cloud of haze of crystal appears in the fuel which is to be tested and thus it is important for low temperature operations. Biodiesel generally has a higher cloud point than diesel.

Table 1: Properties of Diesel and Blends of WCO

Fuels	Calorific Value (kj/kg)	Kinematic Viscosity@ 40°C (cst.)	Flash point (°C)	Density(kg/m3)
Diesel	42390	3.53	69	840
B-10	39800.10	3.72	72	860.4
B-20	39171.16	3.75	73.6	870.4
B-30	38395.5	3.89	77.10	874.2
B-40	37813.75	4.10	79.20	884.4
B-50	37232	4.25	85.22	892.4
B-100	36456.33	4.89	164	895

EXPERMENTATION AND TEST SETUP:

1) Experimental set up:

The schematic diagram of experimental set up as shown in figure7.2.3. The engine set up shown is single cylinder water cooled diesel engine. The engine has rated output 5.2kw at speed 1500rpm with compression ratio 17.5, injection pressure 180kg/cm3 and coupled with rope break dynamometer. The detailed specification of engine is given in table no7.2.1. Performance test are carried out on compression ignition engine using various blends of biodiesel and diesel as fuel.

2) Engine technical specifications:

Engine speed	1500 rpm
BHP	5
Bore	80 mm
Stroke	95 mm
No. of cylinder	1
Dynamometer	Mechanical loading
Drum diameter	28 cm
Do	24 mm
C_d (Coefficient of discharge)	0.6

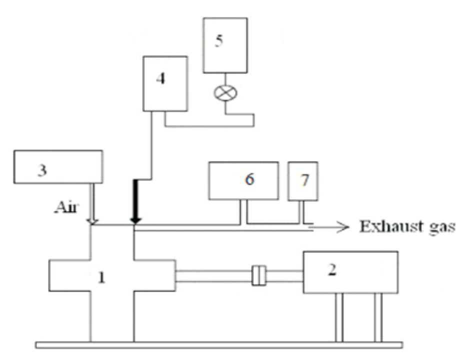

Fig7: Engine Specification

1.Engine 2. Dynamometer 3.Air plenum 4.U-tube manometer
5.Dual biodiesel tank 6.Exhaust gas analyzer 7. Smoke meter

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Procedure:

For Pure Diesel

First, the tank was filled with conventional diesel and cooling water was supplied.

Engine was started and run at no load condition for 4-5 mins.

Then the burette connected with fuel tank and was filled up to 20cc.

Subsequently the time to consume 20cc was noted.

Simultaneously the time taken for1000ml discharge of cooling water was noted and its temperature was measured.

The pressure head was calculated from the difference between the levels in the U-shaped Manometric tube.

Finally the temperature of the exhaust gas was noted.

The same procedure was followed with successive increase in load maintaining the speed constant.

For different blend of biodiesel

The engine was allowed to run continuously until the entire earlier diesel was consumed.

Then the engine was allowed to run for 5 min for obtaining reliable results.

The same procedure for conventional diesel was followed for different blends at different loads.

Fig8: Single cylinder four stroke engine

Performance Parameters:

We had carried out the testing of various blends of biodiesel for the study of their behavior on working condition of four stroke single cylinder diesel engine. This testing enables us to determine various parameters which determine the fuel performance in the engine, which are listed below:

Brake power
Brake specific fuel consumption
Brake mean effective pressure
Air-fuel ratio
Volumetric efficiency
Brake thermal efficiency

a) Brake Power:

The measurement of power involves the measurement of torque as well as speed. The speed is measured by tachometer and torque by dynamometer. For this purpose we will go to use single rope break dynamometer which is mounted at the output shaft of the engine. The power developed by an engine at the output shaft is called the brake power.

$BP = 2\pi NT/60000$ (kW)

b)Mean Effective Pressure:

It is defined as " a hypothetical pressure which is thought to be acting on the piston through the power stroke" .If the mean effective pressure is based on brake power, it is called the break mean effective pressure (BMEP) and if it based on indicated power, is called as indicated mean effective pressure (IMEP).

$BMEP = 60 \times BP/100 \times LAn$ (bar)

c) Volumetric efficiency:

Volumetric efficiency of an engine is an indication of measure of degree of to which the engine fills its swept volume. It is defined as the ratio of the mass of air induced in to the engine cylinder during the suction stroke to the mass of air corresponding to the swept volume of engine of atmospheric pressure and temperature.

$\eta vol = (v_a/v_s) \times 100$ (%)

d) Brake specific fuel consumption:

Specific fuel consumption is defined as "amount of heat consumed per unit of power developed per hrs". BSFC is determined on the basis of brake power of the engine while indicating specific fuel consumption is determine on the basis of the indicated power of the engine.

$BSFC = m_f/BP$ (kg/kw-hr)

e) Thermal efficiency:

Thermal efficiency of an engine defined as the ratio of the output to that of the chemical energy input in the form of fuel supply. It may be based on break or indicated output.

$\eta th = BP/m_f \times CV$ (%)

ENGINE PERFORMANCE AND EMISSION PARAMETERS FOR BIODIESEL BLENDS COMPARED WITH DIESEL:

BP V/S BTE

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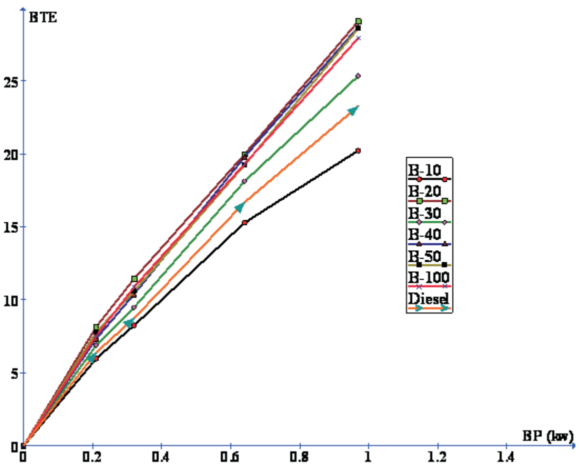
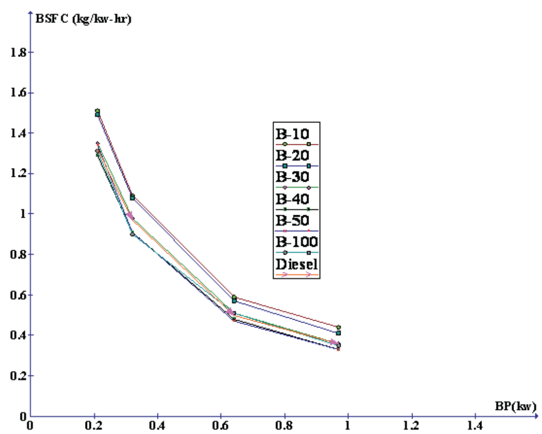


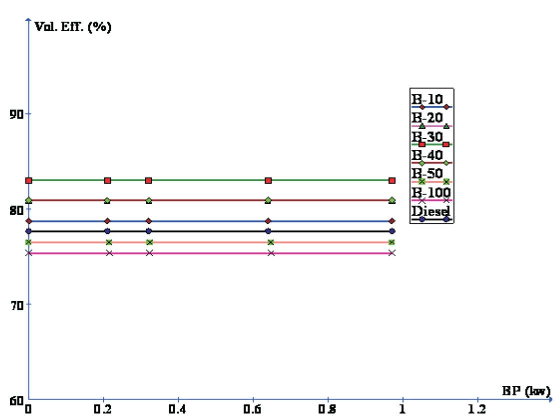
Graph 1: Variation of brake thermal efficiency at different brake power

BP V/S BSFC



Graph 2: Variation of brake specific fuel consumption at different brake Power

BP v/s Vol. Eff. (%)



Graph 3: Variation of volumetric efficiency at different brake power

Engine Load v/s Exhaust gas. Temp.

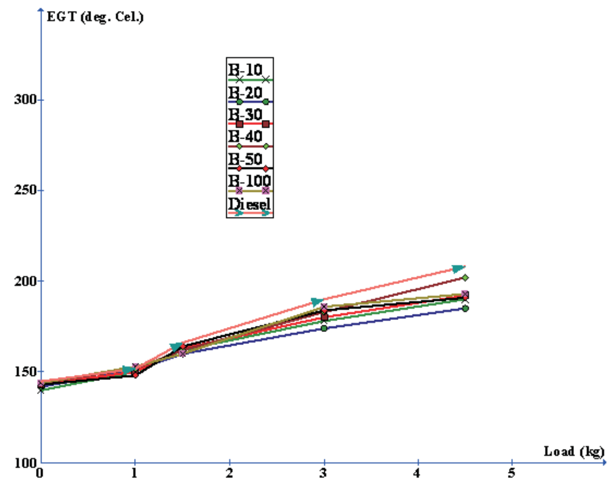
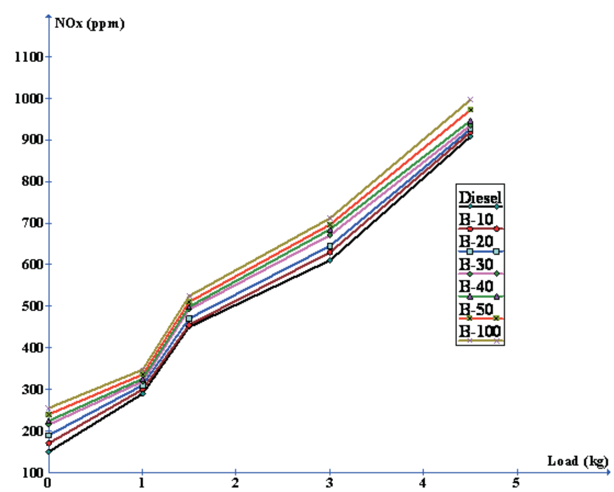


Fig 4: Variation of exhaust gas temp. at different engine load conditions.

Engine Load V/S Nox



Graph 5: Engine load vs Nox

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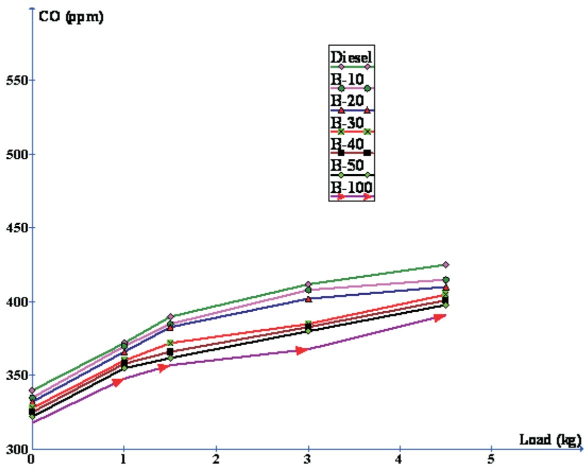
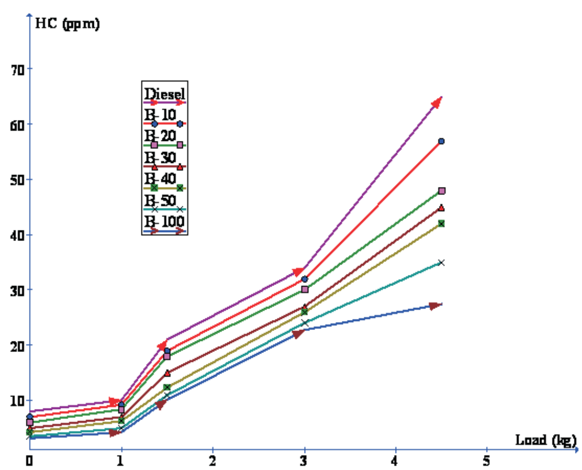
Engine Load V/S CO



Graph 6: Engine load vs CO

Engine Load V/S HC



Graph 7: Engine load vs HC

CONCLUSION

Using biodiesel as a fuel causes an improvement in engine performance and exhaust emissions. Biodiesel has become increasingly important due to the environmental consequences of fossil fuel based diesel engines and the decreasing petroleum resource. The main challenges in the production of biodiesel are its cost and availability of fats and oils resources. By collecting used frying oils and converting them to biodiesel fuel, the cost of biodiesel is significantly lowered and the negative impact of disposing used oil to the environment reduced. However, in the process of frying, oil undergoes many reactions leading to the formation of many undesirable compounds such as polymers, free fatty acids and many other chemicals. These impurities create a lot of challenges in the transesterification of WCO (waste cooking oil). The pretreatment of the WCO (waste cooking oil) to remove these chemicals is not practical; hence the oil is heated and filtered to remove solid particles prior to transesterification reaction. Therefore heating the oil may enhance the yield and productivity of the transesterification reaction that may increase the biodiesel production. Review represents preparation of biodiesel from waste cooking oil.

These investigation leads to conclude that biodiesel which are made from waste cooking oil with diesel fuel can be use as an alternative fuel and has low emission rates. In exhaust parameter NOx is increases with increase in blend proportion and CO, HC decreases with blend proportion. If engine load increases then brake thermal efficiency is increases in Blend (B-20) as compared to other fuels. Blends (B-20) and (B-40) has nearer volumetric efficiency.

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