



An Experimental Investigation to Study the Performance and Emission Characteristics of Chicken Fat Oil Fuelled DI Diesel Engine

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(Received February 16, 2017; accepted July 30, 2017)

ABSTRACT

The importance of biodiesel as a renewable and economically available alternative to fossil fuel for applications in Compression Ignition (CI) engines has led to intense research in the field over the last two decades. This is predominantly due to the depletion of petroleum resources and increasing awareness of environmental and health impacts from the combustion of fossil fuel. Biodiesel is favored over other biofuels because of its compatibility with present day CI engines, with no further adjustments required to the core engine. Such as carbon monoxide, Sulphur oxides, unburnt hydrocarbons and particulate matters are potentially reduced. The effects of biodiesel on nitrogen oxides emission require further tests and validations. The improvement in most of the diesel emission species comes with a trade-off in a reduction of brake power and an increase in fuel consumption. The outcomes completely corroborate the assumption which claims that adding biodiesel to conventional diesel fuel has a strong influence on lowering CO₂, CO, HC, Oxides of Nitrogen and smoke.

Keywords: Compression Ignition engine; Carbon dioxide; Carbon monoxide and Hydrocarbon.

1. INTRODUCTION

1.1. Internal Combustion Engine

An engine is a device which transforms one form of energy in to another form. However, while transforming energy from one to another the efficiency of conversion plays an important role. Normally most of the engine converts thermal energy into mechanical work and therefore they are called heat engine. Heat engine is a device which transforms the chemical energy of the fuel into thermal energy and utilizes this thermal energy to perform useful work. Heat engine classified into two categories: (i) Internal Combustion Engine (IC Engines), (ii) External Combustion Engine (EC Engines).

Engine whether Internal Combustion or External Combustion are of two Types, (i) Rotary Engine, (ii) Reciprocating Engine. The most widely used once are reciprocating internal combustion engine, The gas turbine engine and the steam engine. the steam engine rarely used now a days .the reciprocating

internal combustion engine have more advantages over the steam engine due to the absence of heat exchanger in the passage of working fluid. In Internal Combustion engine higher thermal efficiency can be obtained with moderate max working presser of the fluid in the cycle, and therefore, the weight to power ratio is less than that of steam turbine plant. Also, it has been possible to develop reciprocating internal combustion engines of very small power output with reasonable thermal efficiency and cost. The application of IC engine includes the automobile industry, power plants, and reciprocating components used in heavy machine and factories.

1.2. Alternative Fuels

Day –to –day, the fuel economy of engines is getting improved and will continue to improve. However the enormous increase in number of vehicles has been meeting the current demand for fuel. Gasoline and diesel will become scarce and more costly in the future. With the increased use and depletion of fossil fuels, alternative fuel technology will become in the coming decades. By motivating the development of



Fig. 1. Experimental Setup.

Li *et al.* (2105) motivated the development of alternate fuels for the IC engines is the concern over the emission problems of gasoline and diesel engine. Combined with other air pollutant system, the large number of automobiles is major contributor to the air quality problems of the world.

Singh *et al.* (2009) surveyed the amount of alternate fuel being used in automobiles. One of the reason for developing the alternate fuel technology is the fact that a large percentage of crude oil must be imported from various countries which control the larger oil fields. Now many of the automobiles has been used alternative fuels in limited qualities. This paves the way for comparison with similar diesel –fuelled vehicles, and simplify fuelling of these vehicles.

The engines used for alternative fuels are modify engine which are originally designed for diesel fuelling. Only when extensive research and development is done over the period, mostly the performance and efficiency can be realized from these engines. Sakthivel *et al.* (2016) conducted performance test and emission test on diesel engine by blending fish oil with diesel. The importance of biodiesel as a renewable and economically available alternative to fossil fuel for applications in Compression Ignition (CI) engines has led to intense research in the field over the last two decades. This is predominantly due to the depletion of petroleum resources and increasing awareness of environmental and health impacts from the combustion of fossil fuel.

2. METHODOLOGY

2.1. Experimental Procedure

Engine performance and emissions have been tested in Diesel Engine. A trademark RAINBOW-LA186, single-cylinder, four-stroke, with speed variation, aircooled and direct-injection diesel engine is used

for tests. Schematic view of experimental test apparatus is shown in Fig.1. Ranger ST-4 brand laser thermometer is used for the measurement of exhaust gas temperature. After the engine is started, the engine temperature reaches the regime temperature using diesel fuel (D2) where the experiments are based on 1000 and 2500 rpm in the range of 500 rpm intervals. Then, instead of diesel fuel, a mixture of fuels is sent to the engine separately, and experiments are repeated.. Gas analyzer of CAPELEC CAP-3200 is used to measure emissions exhausted from the test engine. The analyzer measures carbon monoxide (CO), hydrocarbon (HC), carbon dioxide (CO₂) and nitrogen dioxide (NO_x). After the engine has reached the operation temperature, the probe of the device is placed in the exhaust pipe. Then, the emissions values are measured by the device were printed out through a printer on the device.

2.2. Transesterification Process

It is the process where renewable resources like animal fats and vegetable oils could be transformed chemically to clean-burning biodiesel. It was believed before, that vegetable oils can be directly used without the need for any preparation or processing. Sarveshwar Reddy *et al.* (2016) & Atul Dhar *et al.* (2014) investigated and identified that residues and deposits from combustion would create some problems in piston rings, fuel injectors, and oil performance.

Through a process of mixing the oils with ethanol or methanol, a reaction called esters are formed as shown in the Fig.2 Esters are relatively insoluble in water. They have this tendency to form a tiny layer in the surface of the water. So water is not a good base for this process. The best tool for the job is acid. The result is the esterified edition of vegetable oil (Dhar & Agarwal 2014) or the esterification biodiesel product.



Fig. 2. Esterification Process.

2.3. Transesterification Procedure

Transesterification has been carried out as done by Asakuma *et al.* (2013).

Step 1

Taking 15-20gms of potassium hydroxide (KOH) pellets.

Step 2

Then dissolved in 50ml of methanol solution with 10ml of sulphuric acid as a catalyst to produce fast reaction with solution.

Step 3

Then the dissolved solution is mixed with 1L of chicken fat oil by means of stirrer.

Step 4

The oil is heated up to 65°C in a beaker. Then the heated oil is agitated using an agitator (stirrer) at 600rpm for 1hour.

Step 5

After that the oil is allowed to rest under atmospheric condition for 24 hours in conical flask.

Step 6

The sediments settle down at the lowest part while the water and oil form separate regions above the oil.

Step 7

The sediment is removed and the oil and water mixture is heated at 100°C to evaporate the remaining water. After the evaporation process the remaining oil is obtained, which is used as biodiesel.

2.4. Esterification and Transesterification Process

Esterification is the process that utilizes an acid that can alter the FFA (free fatty acids) chains far from the molecule of glycerol, thereby allowing methanol to stick to them and develop into biodiesel.

Transesterification process is the method that utilizes a base compound as the important catalyst to split the FFA chains from the molecule of glycerol then let methanol thereby allowing methanol to stick to them to create biodiesel. The esterification process uses sulfuric acid and it is also called as the Acid method. Transesterification process uses Potassium Hydroxide or Sodium Hydroxide. It is referred to as the Base method. Transesterification process is shown in Fig.4 When chemical structures of FOME and CFME are examined it could be clearly seen that they contained 31.11, 27.74 wt% saturated free fatty acids, 53.76, 70.68 wt% unsaturated free fatty, respectively, Oleic acid (C18:1), palmitic acid (C16:0) and docosahexa-enoic acid (C22:6) were the three major components of FOME and CFME. Hossain *et al.* (2013) & E. Rajasekar *et al.* (2014) identified that oleic acid oils are good for oxidation resistance, these oils have caused rise to the fore as an alternative fuel for diesel engines. Oils that contain fatty acids having single, double bonds are alternative oils for diesel engines; however, cetane number will be adversely affected with increasing unsaturation degree of fatty acid (Rajasekar & Selvi, 2014).The high saturated fatty acids result in biodiesel with a high cetane number. The higher cetane number of biodiesel have many advantages, such as shorter ignition delay, lower NOx emissions, good combustion characteristics, and lesser occurrence of knocking phenomena in combustion process. The cetane number of FOME and CFME is higher than D2 fuel that shows FOB20 and CFB20 blend fuels should be used as an alternative fuel in diesel engines compared to D2 fuel.

2.5. Production of Waste Oil Methyl Esters and Their Blends

Using waste oils in biodiesel production is extremely important because it provides recycling and eliminating waste that it threatens environment and human health. Biodiesel is a fuel that has biodegradable and renewable degradation able structure. It is not toxic, carcinogen, and allergic. It provides very good lubrication. It can be used in all kinds of diesel-powered vehicles and also used for heating purposes. Nitin M *et al.* (2016) pointed the fact that biodiesel has better properties than petroleum diesel; as it is renewable, biodegradable, non-toxic, and essentially free of sulfur and aromatics. Biodiesel seems to be a realistic fuel for future; it has become more attractive recently because of its environmental benefits. Abhishek Sharma *et al.* (2015) experimentally proved that biodiesel is an eco-friendly fuel. It can be used in any diesel engine without modification. It is only possible to use waste oils or fats as fuels in internal combustion engines either by improving fuel properties or making changes in engine structure. However, Tesfa *et al.* (2013) showed the needed changes are in the category of injection pressure and timing. It is recommended that remove the fatty acid will decrease the viscosity of fuel oil. In order to reduce the viscosity of the oil/ fat, fish oil and chicken fat methyl esters are produced by using a chemical method which is called as transesterification method. In a study, it is specified

that the optimum operating parameters for biodiesel conversion process are provided by reducing the FFA of chicken fat. Hence, before it is subjected to basic catalyst in transesterification process FFA is reduced with pre-improvement process by an H_2SO_4 catalyst.

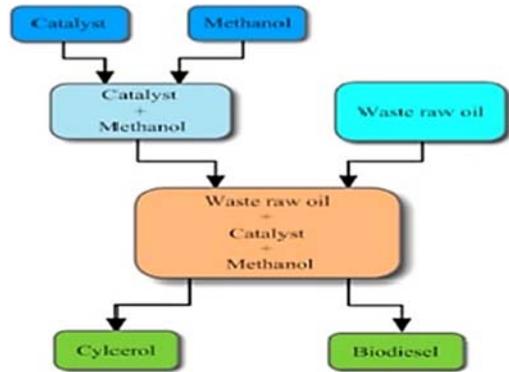


Fig. 3. Biodiesel production stages.



Fig. 4. Transesterification Process.

The production process of oil methyl esters is carried out in stages as indicated in a schematic way

in Fig. 4. The concentration of H_2SO_4 was 2% volumetrically for CFME production in order to reduce FFA content of chicken fat below 1%. of H_2SO_4 was 2% volumetrically for CFME production in order to reduce FFA content of chicken fat below 1%. Waste anchovy fish oil and waste chicken fat biodiesel production steps have been outlined as follows: (i) Presence of water in waste oil causes saponification, depletion of the catalyst and reduction in catalyst efficiency. Therefore, waste oil is put in an open mouth beaker at different times and is heated up to 110 °C in order to evaporate the water in the oil, and it is to be cooled to 60 °C in room temperature. (ii) The mixture of both fish oil and chicken oils are stirred in magnetic stirrer for 2 h at temperature of 60 °C. To prevent loss of alcohol during reaction, a wet cloth is kept on top of reaction vessel. (iii) At the end of the reaction phase of the separation of ester and glycerol, the mixture is stored at room temperature for 8 h. At the end of this period, Glycerol and ester phases are separated from each other and glycerin is taken into separation hopper. Obtained biodiesel is filtered through cloth filters and washing process is taken up. (iv) For the possibility of water in the biodiesel in separation funnel, the water is heated above the boiling point of 100 °C and to make it evaporate. As a result, lower viscosity methyl esters (FOME and CFME) are obtained.

3. RESULTS AND DISCUSSION

3.1. Performance Results

The performance tests were conducted with the various blend properties of Diesel-chicken fat oil fuels. The performance parameter such as Brake power, Brake Thermal Efficiency, Indicated power, Friction power, Total fuel consumption with the base diesel fuel and performance of the blended Chicken fat oil-Diesel Fuel was analyzed.

3.1.1. Brake Thermal Efficiency

The performance of the Diesel-Chicken fat oil blends was calculated by relating the Brake power to input Load in terms of percentage as said by Akash Deep *et al.* (2017). The fuel consumptions was determined by the time of consumption of fuel for 10 CC. Fig. 5 shows the variation in brake thermal efficiency for the different proportion of Diesel-Chicken fat oil blends in a direct injection Diesel engine.

3.1.2. Mechanical Efficiency

The mechanical efficiency of the Diesel-Chicken fat oil blends was calculated by relating the brake power to Heat input. The output power is calculated with the current given to the field for stator the electromagnets. The Fig. 6 shows the variation in mechanical efficiency for the different proportion of Diesel-Chicken fat oil blends in a direct injection Diesel engine.

The mechanical efficiency of the engine fuelled with B20 is higher than the other blends.

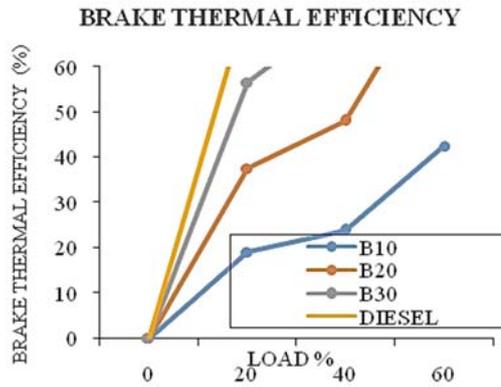


Fig. 5. Load Vs. Brake thermal efficiency.

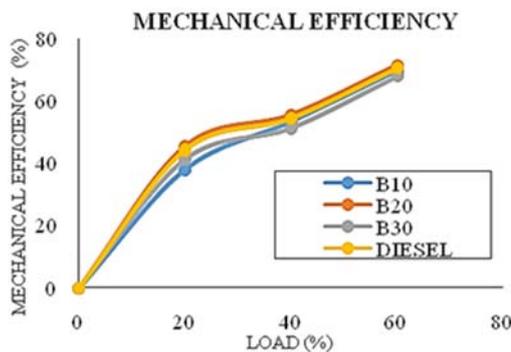


Fig. 6. Load Vs Mechanical Efficiency.

3.1.3. Total Fuel Consumption

The Total Fuel Consumption of the Diesel-chicken oil blends was calculated by relating the brake power (output) to Heat input (Fuel power). The output power is calculated with the current given to the field for stator the electromagnets

The fuel power was determined by Fig. 7 shows the variation in Total Fuel Consumption for the different proportion of Diesel-Chicken fat oil blends in a direct injection Diesel engine.

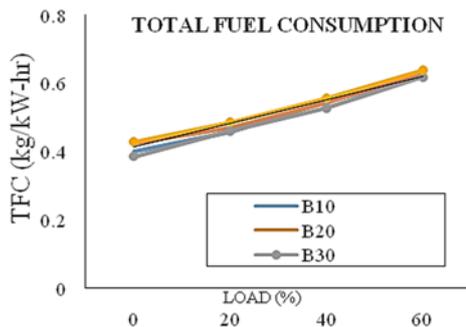


Fig. 7. Load Vs Total fuel consumption.

3.2. Emission Characteristics

The exhaust gas emission test at different loading condition for the various blending ratio Diesel-Chicken fat oil fuels are examined with the help of AVL DI gas analyzer.

3.2.1. Carbon Monoxide Emissions

When there is not enough oxygen to convert all carbon to CO₂, some fuels does not burned and some carbon ends up as CO. Because of using oxygenated fuel it reduces the CO emissions in the blending. Fig. 8 shows the CO emission level for various loading condition of the engine the different proportion of chicken oil in the diesel fuel.

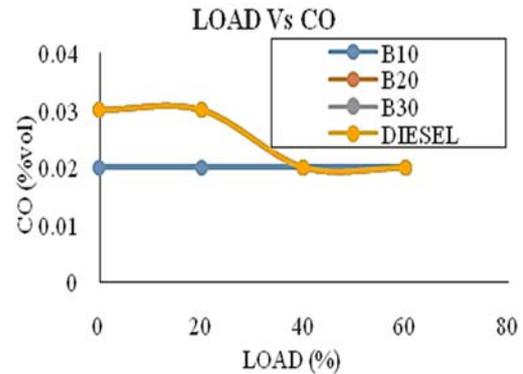


Fig. 8. CO emission of the Blended Fuels.

3.2.2. Carbon Dioxide Emissions

The graphs are plotted between different loads of the engine to the emissions of carbon di oxide (CO₂) in the Fig.9 For the higher blending ratio the CO emission is slight increase due to the non-homogeneity of fuel-air mixture will lead for lean mixture to combust properly.

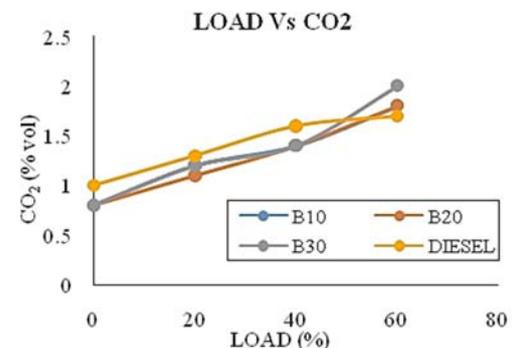


Fig. 9. CO₂ emission of the Blended Fuels.

3.2.3. Hydrocarbon Emission

The Hydrocarbon emission of the different blends was tested with various load condition of the engine. Fig. 10. shows the variation in the emission level of the hydrocarbon for the addition of chicken oil in the diesel fuel. According to Hyun Gu Roh *et al.* (2014) for higher blending ratio, a slight increase in the emission level of HC is observed due to the non-homogeneity of fuel-air mixture. The homogeneity will lead to lean mixture formation and combusts properly. Hydrocarbon (HC) emissions occur in regions consisting of non-complete combustion. HC emissions are not directly related to the engine load

and speed. It more depends on the geometry of the injection system and combustion chamber. When the amount of air breathing capacity of engine is increased the oxygen content in the chamber is also increased. This will reduce the amount of unburnt hydrocarbon emitted. Hydrocarbons also contain a wide variety of organic chemical substances, and they do not have the toxic effect in the normal atmospheric conditions. However, Ashok *et al.* (2016) found the reactions of other exhaust species combined with the air can cause considerable pollution. There are significant increases in the amounts of hydrocarbons in areas with high motor vehicle traffic volumes (Ashok *et al.* 2016). The exhaust emissions of unburned HC are shown with respect to a different number of revolutions at full load. As shown in the figure, unburned HC emissions of blend fuels (FOB20 and CFB20) are lower than D2 fuel. When compared with D2 fuels, the amount of decrease in hydrocarbon emissions is found to be 12.89%. This amount is very important in the point of thermal performance of the engine. The higher HC is exhausted in emissions, the lower engine performance is obtained from an engine.

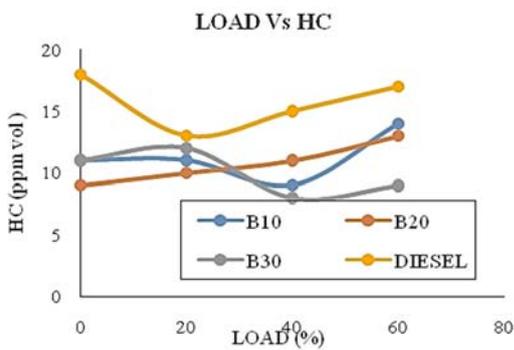


Fig. 10. HC emission of the Blended Fuels.

3.2.4. Oxides of Nitrogen Emissions

The Oxides of Nitrogen are exhaust due to the presence of nitrogen in the Air used for the combustion. In this emission characteristics of the blended chicken oil fuel for the Diesel are plotted below in Fig. 11 Two important parameters that influence the formation of NO_x are combustion chamber temperature and air–fuel ratio. When the combustion chamber temperature increases above 1800K, nitrogen and oxygen are chemically combined in the air and becomes nitrogen oxides which are harmful for human health and environment. Nitrogen oxides combine with moisture in the lungs by forming nitric acid and lead to a respiratory disease. As a result, diluting the mixture with exhaust gases in the combustion chamber causes to reduce both the combustion temperatures and the amount of NO_x produced. As per Alessandro *et al.* (2016), nitrogen affinity with oxygen at high temperature increases the emissions of NO_x rapidly. Nitrogen oxides are among the gasses in greenhouse gases that threaten human health. Therefore, nitrogen oxides are requested to be as little as possible in the air. Nitrogen oxide formation in diesel engines depends on injected fuel

quantity, injection time, the amount of air taken into the cylinder and temperature. By addition of chicken fat oil to diesel fuel decrease the content of carbon and hydrogen in the blend solutions. This provides an additional beneficiary effect of reducing the NO_x emission as shown in Fig 11.

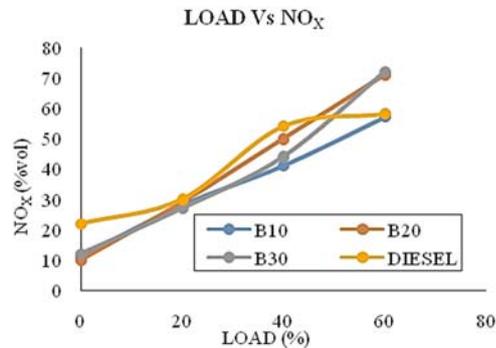


Fig. 11. NOx Emission of the Blended Fuels.

4. CONCLUSION

When the interest of creating a new fuel blend in the automobile field, the preparation of diesel- Chicken fat oil has been done as fish oil was successfully utilized in DI-Diesel engine. The performance of DI-DIESEL engine with the blended fuels has been increased and also the emission test results have been given and new hope to use these kind of fuel to the society for creating an eco-friendly environment. From this paper, it is concluded that for higher blended fuels the Brake thermal efficiency the maximum at low loading condition. For producing high brake power the total fuel consumption is relatively low. The CO emission at maximum loading condition is lower for higher blended fuel. By using this alternative fuel the complete combustion can be achieved easily.

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