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Investigation of Emission Properties and Performance Characteristics of Biodiesel from Chicken Waste

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***Abstract*—In India, chicken farms supply chicken to small shops called "Chicken Stalls" where they are usually slaughtered and cut. Indians usually ask for skinless chicken when ordering from these shops. Therefore, the skin is disposed of from these shops. This skin is disposed usually in the public drain and therefore becomes potentially hazardous solid waste in the environment. After seeing the excess of chicken skin/fat in the market, we realized that this waste could be used to create biodiesel. This biodiesel could be used to power automobiles (with modified engines), for domestic purposes and biodiesel could also be a cheaper source of fuel compared to refinery diesel.**

Fat from the waste chicken skins (sourced from local shops), was first extracted but the viscosity of these animal fat based oil is higher, so these can be brought down by a process known as "Transesterification" which is the process of exchanging the organic group R″ of an ester with the organic group R′ of an alcohol. These reactions are often catalyzed by the addition of an acid or base catalyst.

An experimental work has been carried out to analyze the emission and performance characteristics of a single cylinder compression ignition engine fueled with mineral diesel and diesel-biodiesel blends. The results of experimental investigation with biodiesel blends were compared with that of baseline diesel.

Keywords—Biodiesel, Transesterification

I. INTRODUCTION

New and renewable alternative fuels as a substitute for petroleum-based fuels have become increasingly important, due to environmental concerns, unstable costs and transportation problems. One of the renewable alternative fuels is biodiesel, which is domestically produced from new or used vegetable oil and animal fat. Oil or fat is reacted with alcohol (methanol or ethanol). This reaction is called transesterification [1]. The reaction requires heat and a strong catalyst (alkali's, acids, or enzymes) to achieve complete conversion of the vegetable oil into the separated esters and glycerine [2]. During the transesterification reaction, glycerine is obtained as a by-product. It is used in pharmaceutical, cosmetic and other industries. Biodiesel not only can be used alone in neat form but also can be mixed with petroleum diesel fuel in any unmodified diesel engines [3].

Diesel fuel is very important for countries economy because it has wide area of usage such as long haul truck transportation, railroad, agricultural and construction equipment. Diesel fuel contains different hydrocarbons (benzene, toluene, xylenes, etc.), sulphur and contamination of crude oil residues. But chemical composition of biodiesel is different from the petroleum-based diesel fuel [4]. Biodiesel hydrocarbon chains are generally 16–20 carbons in length and contain oxygen at one end. Biodiesel contains about 10% oxygen by weight. Biodiesel does not contain any sulphur, aromatic hydrocarbons, metals and crude oil residues. These properties improve combustion efficiency and emission profile. Biodiesel fuel blends reduce particulate material (PM), hydrocarbon, carbon monoxide and sulphur oxides. However, NOx emissions are slightly increased depending on biodiesel concentration in the fuel. Due to the lack of sulphur biodiesel decrease, levels of corrosive sulphuric acid accumulating in engine crank case oil [5].

II. MATERIALS AND METHODS

A. *Materials*

The materials used for the experiment were waste chicken skin, methanol, sodium hydroxide pellets.

B. *Apparatus Used*

- Beakers of 500ml each
- Beakers of 2L each
- Electronic balance accurate to .01g
- 1 Pressure cooker of 5L capacity
- 1 Kitchen knife
- 1 magnetic stirrer
- measuring cylinders of 1L capacity
- 1 stove top
- 2 vertical clamp stands
- glass rods

C. *Procedure*

About 900g of waste chicken skin was bought from chicken stalls. The skin sample was manually de-feathered. After the skin was de-feathered, it was thoroughly washed using tap water. It was then cut into long pieces that were immersed (not dissolved) in water inside a 1 L, borosil beaker. The contents of this beaker were poured into a vessel that was set inside a pressure cooker, which was quarter-filled with water. The mixture was cooked under a medium flame for about nine and a half minutes, and was taken out and filtered into another, washed beaker.

The liquid portion obtained was separated into layers using Chloroform ($CHCl_3$). The three layers obtained were: a solid layer, aqueous and a layer containing triglycerides (or an organic/fat layer). The solid layer was separated from the aqueous and the organic layers using a filter funnel and filter paper, and the aqueous layer (which, in this case was white in color) was separated from the organic layer using a separating funnel. The organic layer was stored, temporarily in a conical flask, and the solid layer (or the solid mass) was thoroughly ground using a blender and was dissolved in approximately 300 mL of water.

The mixture formed was further cooked in a pressure cooker by pouring the mixture into a vessel that was, once again, immersed into a pressure cooker quarter-filled with water and was allowed to cook. After seven minutes, the cooked solid layer was removed, and was filtered out to get rid of any solid sediment (known as solid mass). The resulting liquid portion was separated in a separating funnel into an organic layer containing triglycerides and an aqueous layer. Chloroform was added to the aqueous layer to extract any remaining fat, and the aqueous layer was disposed along with the solid mass.

Due to the optimum temperature of this reaction being approximately 68 ^{0}C, the extracted fat sample was placed on a magnetic stirrer that was set to 68 ^{0}C. A thermometer was also placed inside the fat sample and was constantly checked to make sure that the temperature of the fat did not go above or below the optimum temperature.

After this, about 4.14 grams of NaOH pellets were dissolved in 156 mL of methanol. Once the pellets completely dissolved in methanol, the resulting solution was poured into the fat sample (that is currently on the magnetic stirrer), and a 2 cm long magnetic stir bar (that, in essence, stirs the two reactants due to the rotating magnetic field brought about by the magnetic stirrer) was placed inside the conical flask in which transesterification was occurring.

After exactly 1 hour, the conical flask was removed from the magnetic stirrer, and the stir bar was taken out using forceps. The contents of the conical flask were then poured into a separating funnel, which was left overnight (approximately 8 hours). There were two layers formed by transesterification; one was a completely transparent layer (glycerine), and one was a translucent yellow layer.

The transparent layer, in this case, was waste glycerol, and the yellow layer was useful biodiesel that was initially washed by gently washing the sample with warm water (at a temperature of about 45 ^{0}C) to get rid of any residual catalysts or soaps. The biodiesel is then dried and subjected to various tests.

D. Experimental setup

The experiment on load test and volumetric efficiency test was done on 4s diesel engine single cylinder with electrical dynamometer when the engine fueled with diesel and its blends in various proportions like 10%, 20%, by volume and then investigate the performance and emission characteristics of C.I Engine at different load and to draw the following graph:

1. Brake power v/s total fuel consumption
2. Brake power v/s specific fuel consumption
3. Brake power v/s volumetric efficiency
4. Brake power v/s air fuel ratio

The test rig ‘Figure 1’ details are given in Table 1.

TABLE I. Test rig detail

KIRLOSKAR SINGLE CYLINDER DIESEL ENGINE		
Sl	ITEM	SPECIFICATIONS
1.	Rated HP	5HP
2.	Speed	1500rpm
3.	Type of stroke	4stroke
4.	Stroke length	110mm
5.	Bore diameter	80mm
6.	Efficiency of alternator	75%
7.	Orifice	20mm
8.	Coefficient of discharge	0.6

Fig 1. Test rig engine

The following procedure was followed for doing the experiments:

1. Started the engine taking following precautions
   - Check the fuel level (diesel or biodiesel).
   - Check the lubricating oil level.
   - Check the cooling water circulation.
   - Check the engine is at no load.
2. After starting the engine, allow the engine to run for few minutes to attain steady condition. Note the speed and manometer reading.
3. Now take the time for the consumption of 20cc of fuel at no load.
4. Repeat the steps with different loads and record the time for 20cc fuel consumption time for 3 revolutions in energy meter and corresponding manometer reading.
5. After the consumption of experiment bring the engine to no load condition before stopping.

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III. RESULTS AND DISCUSSION

A. Comparison of different fuels with their engine performance

In Figure 2, Brake power is taken in x-axis and is taken TFC in y-axis. The TFC of the blends has been compared with diesel fuel at various loads and it is shown in figure. It is observed that the TFC is less for the B10 over the entire range of load.

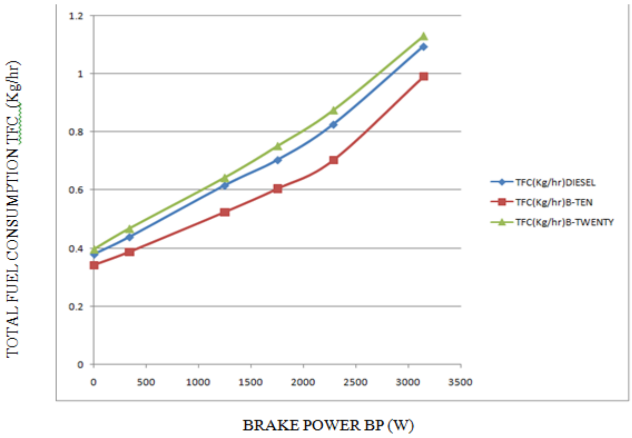

Fig 2. Brake Power vs Total Fuel Consumption

In the Figure 3, Brake power is taken in x-axis and is taken SFC in y-axis. The SFC of the blends has been compared with diesel fuel at various loads and it is shown in figure. It is observed that the SFC for B20 blend was considering lower for first three loads remaining the B10 is lower over entire load range.

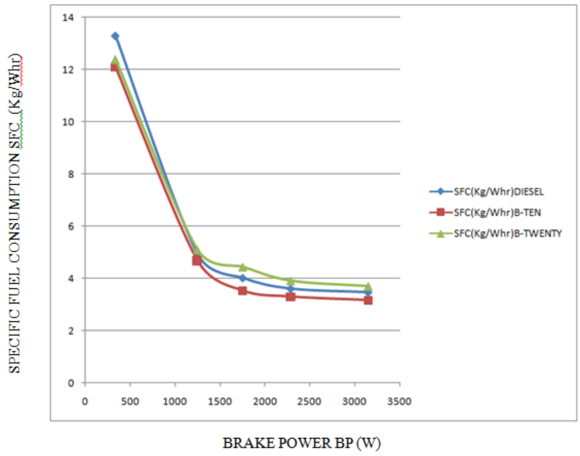

Fig 3. Brake Power vs Specific Fuel Consumption

In the Figure 4, Brake power is taken in x-axis and Volumetric Efficiency should be taken in y-axis. The volumetric efficiency of the blends has been compared with diesel fuel at various loads and it is shown in figure. It is observed that the Volumetric Efficiency for B20 blend was considering Higher over entire load range.

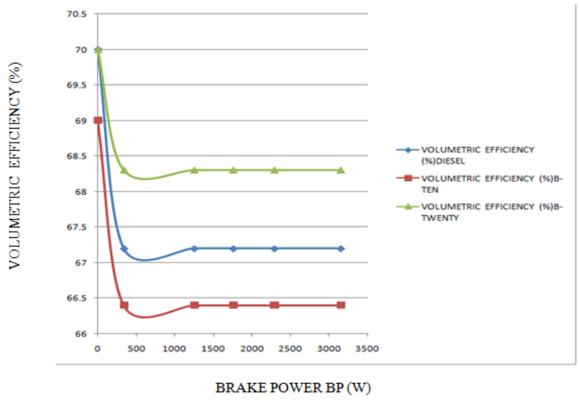

Fig 4. Brake Power vs Volumetric Efficiency

In Figure 5, Brake power is taken in x-axis and air- fuel ratio should be taken in y-axis. The air- fuel ratio of the blends has been compared with diesel fuel at various loads and it is shown in figure. It is observed that the air- fuel ratio for B20 blend was considering lower over entire load range.

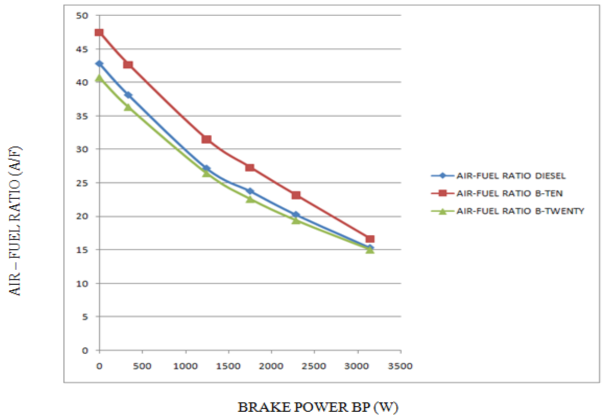

Fig 5. Brake Power vs Air- Fuel Ratio

From Figure 6, the variation of carbon monoxide with load can be observed for all the biodiesel blends –Diesel fuel blends. The results show that CO emission of biodiesel blends is lower than Diesel fuel. With increase in power output, the CO emission gradually reduces for B10 and slight increase for B20 and the difference in the values for CO emission with Diesel fuel reduces significantly.

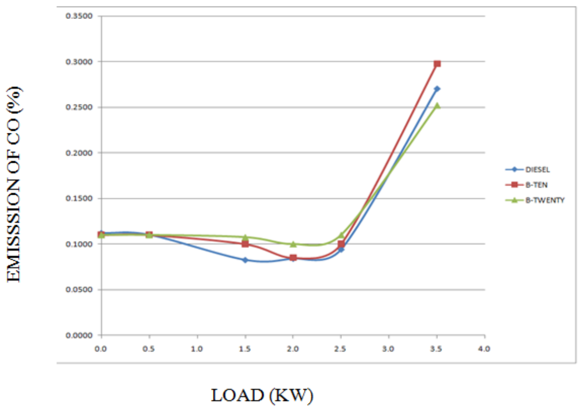

Fig 6. Brake Power vs Emission of CO

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As shown in Figure 7, it can be observed that the variation of carbon dioxide emission with load for Diesel Fuel and Diesel fuel blends. From the results, it is observed that the amount of CO_2 produced while using Diesel fuel blends is lower than Diesel fuel at all loads except full load. This may be due to late burning of fuel leading to incomplete oxidation of CO.

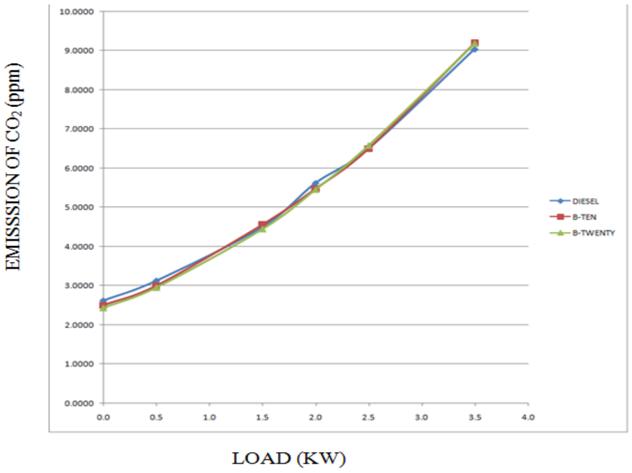

Fig 7. Brake Power vs Emission of CO_2

The variation of hydrocarbons with load for tested fuels is depicted in Figure 8. From the results, it can be noticed that the concentration of hydrocarbon of Diesel fuel blends is less than Diesel fuel. With increase in power output, the HC emission gradually increases for Diesel fuel blends.

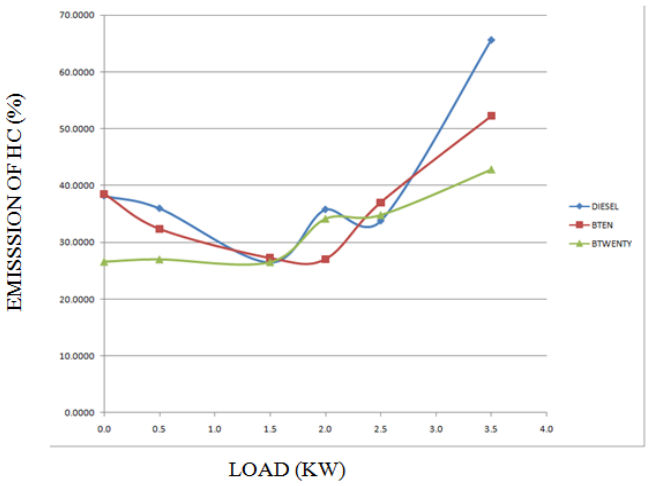

Fig 8. Brake Power vs Emission of HC

It is clear that oxygen present in the exhaust gas is decreases as the load increases. It is Obvious that due to improved combustion, the temperature in the combustion chamber can be expected to be higher and higher amount of oxygen is also present, leading to formation of higher quantity of NO_x Diesel fuel blends as shown in Figure 9 and Figure 10.

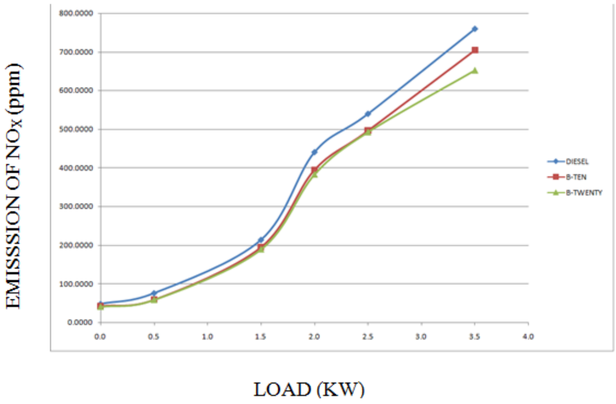

Fig 9. Brake Power vs Emission of NO_x

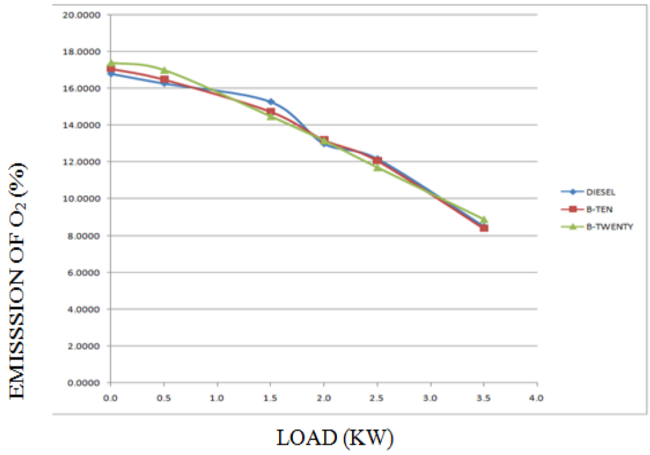

Fig 10. Brake Power vs Emission of O_2

IV. CONCLUSIONS

A Single Cylinder Four Stroke Compressed Ignition Engine was operated successfully using the diesel and diesel blends as fuel. The following conclusions are made based on the experimental results: The Total Fuel Consumption is less for the B10 over the entire range of load. The Specific Fuel Consumption for Blend 20 is less when compared to diesel and all other blends over the entire load range. The Volumetric Efficiency for B20 is more than diesel over the entire load range. The Air- Fuel Ratio for B20 blend was considerably lower over entire load range. Carbon monoxide emission from the exhaust gas is reduced as the output power increases but this concentration is increased as the blend increase with the diesel fuel. Hydro carbon emission is found to be lesser in concentration than the diesel at all load conditions for the diesel blend fuels, but hydrocarbon emission slightly increases higher as load increases. Carbon dioxide emission is increased as the load variation increased but the concentration is less when compared to the diesel fuel operation. Oxygen content of blended diesel fuels is reduced from the exhaust gas as the load is increased and again starts to increase. If the high content of oxygen is present in the exhaust then its results in better combustion. No_x emissions in B20 and B10 were low compared to diesel.

Following conclusions have been made from the production of Biodiesel. 10kg of chicken waste used to produce 300ml of extracted oil. 300ml of extracted oil is used to produce 175 ml of biodiesel. Current Price of diesel = Rs53.98/L. Price of our biodiesel is Rs142/L. Commercially price of biodiesel is Rs. 44.86/L. Price of our blended diesel fuel B20 is Rs. 44.86/L.

So, it is preferred to use the B20 blend, as a best blend to the diesel due to the following reasons: Lowest specific fuel consumption reduces the expenditure on fuel. The power utilized is more from the developed power than other blends. Low exhaust gas temperature results in decreasing the environmental pollution. As the volumetric efficiency is good sufficient amount of air is available to the fuel, so the emission is due to incomplete combustion is lowered. As price of blended diesel fuel B20 is Rs. 44.86/L.

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