

Performance and Emission Characteristics on Diesel Engine using Waste Chicken Fat Oil Biodiesel as Fuel

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Abstract- According to the survey of the oil and gas journal, crude oil production is expected to reach a peak somewhere between 2015 to 2025 and from then it is eventually going to decrease. Thus need to look at other options as far as energy need is concerned. The present study is focused on investigation of CI engine by using biodiesel which is produced from the waste chicken fat oil. Here waste chicken fat was taken to extract oil from it and that oil is used in the biodiesel production process namely transesterification. And the produced biodiesel was taken to check the properties of it such as calorific value, viscosity, density, flash and fire point. And also the property value meets the ASTM standard for biodiesel. After that the analysis were carried out for various biodiesel blends produced such as B20, B40, B60, B80 and B100 by varying the load conditions such as 25%, 50%, 75% and 100% on engine. By the way engine performance and emission characterization are analyzed in brief. Results shows that the use of chicken fat oil biodiesel for substitution of diesel fuel was good without modification on engine. By considering performance parameter the brake thermal efficiency increases and brake specific fuel consumption decreases on using chicken fat oil biodiesel (CFBD) was observed. Slightly lower NOX and higher HC and CO emissions are noted on using biodiesel in engine emission test. However by compared to pure (D100) diesel fuel 22.03% higher NOX and 24.05% lower CO with 46.15% lower HC were observed with chicken fat oil biodiesel.

Keywords – Biodiesel, Chicken fat oil, Engine performance, Engine emission, Transesterification process.

I. INTRODUCTION

Increasing of petrol and diesel price day by day emerges to find a new fuel like some alternative fuels; this idea leads to get renewable energy source such as biodiesel for diesel engines. The biodiesel is one of the best alternative fuels which prepared from vegetable oil, animal fats, and recycled cooking oil. Biodiesel is renewable and environmental friendly alternative diesel fuel. The technical definition of biodiesel is mono alkyl esters of long fatty acids. The most important method to produce biodiesel is called transesterification.

K Srinivasa Rao et al. [1] investigated DI-CI engine characteristics with preheated chicken fat biodiesel. They obtained performance and emission characteristics very close to petroleum diesel with preheated chicken fat biodiesel blend. NOX emissions are more for chicken fat biodiesel compared petroleum diesel. Jagadale S.S and Jugulkar L.M [2] studied single cylinder, 7.5HP power at 1500rpm constant speed, Kirloskar diesel engine characteristics using blends of chicken fat based biodiesel. They observed that thermal efficiency, specific fuel consumption, volumetric efficiency and mechanical efficiency of the engine with chicken fat biodiesel (CFBD) blend with diesel are nearly equal to pure diesel. They reported that chicken fat is one of the cheap raw materials for

making biodiesel. Kambiz Tahvildari A et al.[3]studied and determined properties of chicken fat biodiesel. They concluded that waste chicken fat is the one of suitable stock material for biodiesel production. Ertan Alptekin et al.[4]used one of the low cost feedstock such as chicken fat for biodiesel production. They studied the effect of catalyst type, reaction temperature and reaction time on the fuel properties such as density, viscosity, flash point, pour point, acid value and heat of combustion. Selva Ilavarasi Panneerselvam et al. [5] attempted to use chicken fat as low cost sustainable potential feed stock for biodiesel production. The study on the biodiesel production process, optimization of chicken fat showed that the quantity of catalyst, amount of methanol, reaction temperature and reaction time are the main factors affecting the production of chicken fat methyl ester. The optimal values of these parameters for achieving maximum conversion of oil to ester depend on the chemical and physical properties of these fats.

II. MATERIALS AND METHODS

A. Waste chicken oil extraction-

1. First 4 kg of waste chicken fat which was collected from the poultry farm was taken and cleaning process was done. Waste chicken fat was shown in Fig-1.
2. After cleaning of chicken fat, it was allowed to heated till it reaches 120°C to lose all it moisture contents.
3. And then chicken fat was strained which in turn filtered it, after filtration process 1 liter of chicken fat oil was obtained as shown in Fig-2.
4. Here 500 ml of purified oil was used for experimentation.



Figure 1. Waste chicken fat



Figure 2. Extracted chicken fat oil

B. Transesterification process-

1. After filtration of 500 ml of oil obtained it was heated for 75°C in a heater.
2. Now in a beaker take and add 150 ml of methanol (30% in oil), 1.75 grams of NaOH (sodium hydroxide) in powder form and allow dissolving for 15 min.

3. Meth-oxide was formed during the above reaction occurs, and which is going to add with fat oil.
4. Now transfer the heated oil to the reactor which transesterification process going to held.
5. Now pour the meth-oxide mixture of (methanol and NaOH) in to the other beaker which is connected to reactor.
6. Now slowly allow the mixture by opening the valve into the flask containing chicken fat oil.
7. By using magnetic stirrer stirring process was done after mixing of meth-oxide in to oil in a reactor because of mixture not to get solidify quickly, the stirrer speed is maintained at 800rpm and carried out for 80 min.
8. Then the mixture was left in a reactor itself for 5 to 6 hours without stirring, after that to check whether glycerin was produced or not by taking few sample mixture of it. And Fig-3 shows the Transesterification process reaction.

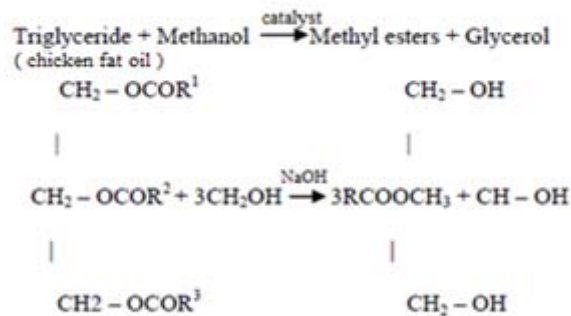


Figure 3. Transesterification Process

9. If the glycerin forms a separate layer then the process was completed, density of glycerin was high compared to biodiesel so the biodiesel was settled on top layer in a reactor.
10. Finally biodiesel and glycerin was separated from the transesterification reactor in the flask separately for testing.

C. Blending of biodiesel -

1. The produced biodiesel was blended with the pure diesel fuel in different percentage on volume basis as shown in Fig-4.
2. The notations are mentioned in the picture denotes the level of biodiesel mixed with pure diesel fuel, for example B20 denotes 20 percent of biodiesel and 80 percent of pure diesel. And Table-1 shows the various properties obtained from the biodiesel.
3. The blending process was done by using equipments such as measuring jar and beaker; hence the appropriate percentage of biodiesel and pure diesel was measured and added to the beaker and the transferred to the large size jar.
4. After that by using stirrer the mixture was stirred and shakes well to obtain proper proportion biodiesel blends.
5. Now the jar contained blended biodiesel was stored in a dry area for some hours about 12 to 16 hours, and blends were checked for every 4 hours time intervals for identification any additional layer formations.



Figure 4. Blended biodiesel produced from chicken fat oil

Table -1 Properties of Biodiesel

S.No	PROPERTIES	D100	B20	B40	B60	B80	B100
1.	Density (kg/m ³)	830	837	845	856	868	880
2.	Viscosity at 40 °C (cSt)	2.58	2.96	3.43	3.88	4.62	5.77
3.	Calorific value (KJ/Kg)	42500	41100	39670	39000	38200	37880
4.	Cetane Number	48	52.6	53.6	55	57.1	58.4
5.	Flash point (°C)	50	72	89	106	125	146
6.	Fire point (°C)	72	93	105	126	141	161

III. EXPERIMENTATION WORK

The single cylinder, four stroke, direct injection diesel engine was chosen for the evaluating performance test on biodiesel. The complete specification of the test engine is shown in Table -2. There is no modification or alteration has been made in the diesel engine. The experimental setup consists of variable compression ratio engine which is coupled with an eddy current dynamometer. The dynamometer is connected to the electric current supply to apply load on the engine. The experiments were carried out for various loading conditions such as 25% (5 NM), 50% (10 NM), 75% (15 NM) and 100% (20 NM) at 1500 rpm constant speed on engine.

The data acquisition system was used here to collect the data's from the system and stored that data's into a computer storage for evaluation of characteristics of engine. Then the pressure generated inside the engine cylinder was measured by piezoelectric pressure transducer, by the same crank angle also measured by using crank angle encoder. Load cell is connected to eddy current dynamometer for measuring loads applied on the engine. And a K type thermocouple used here to measure the inlet air temperature and exhaust gas temperature.

Table -2 Engine specification

S.No	PARAMETERS	SPECIFICATION
1.	Engine made	Kirloskar engine (AVI)
2.	Type of engine	Single cylinder, four stroke, compressed ignition engine
3.	Fuel	Diesel
4.	Max power/Rated speed	4.23 KW/1500 rpm
5.	Compression ratio	17.5:1
6.	Bore & stroke	80mm & 110mm
7.	Injection pressure	200 to 225 bar
8.	Dynamometer	Eddy current type
9.	Swept volume	556 cc
10.	Cooling method	Water cooled type

A burette with two infrared optical sensors adopted here to measure fuel flow rate and the air flow sensor was used here for measuring inlet air flow rate. AVL smoke meter allows to measure the smoke produce from the engine and AVL DIGAS analyzer is used here to measure the exhaust gas constituents such as NO, CO and HC.



Figure 5. Experimental setup

All the experiments were conducted at constant compression ratio of 17.5:1 and the results are recorded. The experimental setup was shown in Fig-5.

In this study, the biodiesel used in the various proportions of 20% (B20), 40% (B40), 60% (B60), 80% (B80) and 100% (B100) were used for conducting performance tests. The term B20 indicates 20% biodiesel and 80% pure diesel. First by using commercial diesel D100 analysis was made, after that by using various blend proportions of biodiesel the tests were carried at a same loading condition taken for pure diesel D100.

IV. RESULT AND DISCUSSION

A. Performance characteristics-

Brake thermal efficiency (BTE):

Brake thermal efficiency is an important parameter in the performance testing on IC engine; it denotes how the chemical energy input is converted into useful work inside an engine. In this study BTE of diesel engine is measured for different blended biodiesel and pure diesel (D100). The variation of brake thermal efficiency with load for diesel fuel, biodiesel and blends B20, B40, B60, B80 and B100 is shown in the Fig-6. It shows that BTE increase with increasing loads on engine, when the load reaches 75% (3.0 KW) it almost shows constant reading. This was due to reduction in heat loss and increase in power with increasing in load. Hence from the graph the maximum thermal efficiency for B20 (20.6%) was higher than that of diesel fuel. And the brake thermal efficiency resulted for B40, B60, B80 and B100 were less than that of B20. This lower BTE is due to reduction in calorific value and increases in fuel consumption as compared to B20.

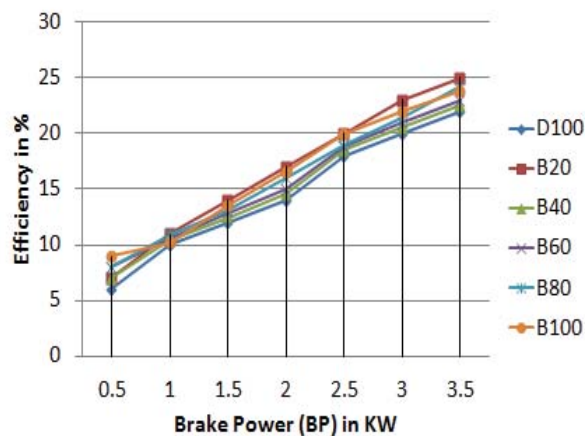


Figure 6. Variation of BTE with BP

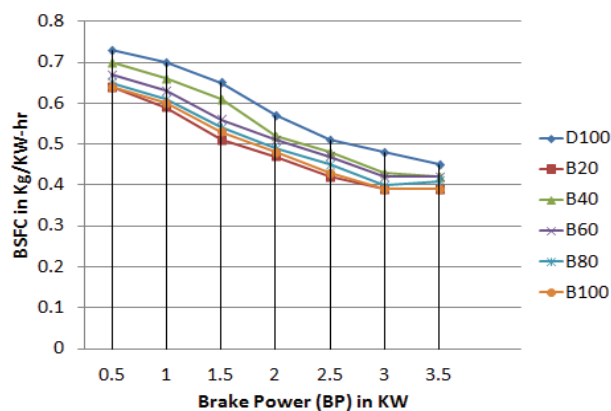
Brake Specific Fuel Consumption (BSFC):

Figure 7. Variation of BSFC with BP

Brake specific fuel consumption (BSFC) is a ratio between mass fuel consumption and brake effective power; it is inversely proportional to thermal efficiency. The variation of BSFC of different blended biodiesel with engine load in brake power was shown in Fig-7. From the graph values obtained below, it is clearly known that BSFC of chicken fat oil biodiesel was higher than pure diesel. This is due to calorific value chicken fat oil biodiesel was lower compared to pure diesel fuel. BSFC decreased continuously with increasing in load. Finally B20 blend shows less in BSFC than the pure diesel and all other blends, this is because of complete combustion of fuel due to presence of more oxygen content in biodiesel blends.

B. Emission characteristics-

Carbon monoxide emission (CO):

Mostly the CO produced from the exhaust emission in engine might convert into CO₂ due to oxygen molecule presents in the fuel. Here in biodiesel the oxygen chain is higher and so due to this reason emission of CO is decreases shown by the emission test result. In Fig-8 it can be clearly shown that the CO initially decreased with increasing load and later increased continuously up to the increasing load for all blends.

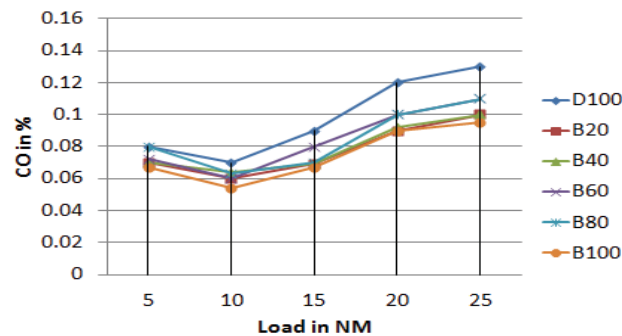


Figure 8. Variation of CO emission with Load

Hydro carbon emission (CO):

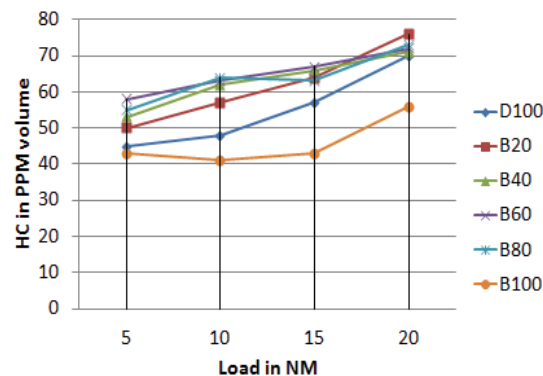


Figure 9. Variation of HC emission with Load

The hydrocarbon emissions for pure diesel and blended biodiesel were shown in Fig-9. By the result shown in the graph it was clearly seen that the HC emission has been reduced with the addition of biodiesel blends during the emission test. This is because of more complete combustion of fuel. Hence the more oxygen content in the biodiesel blends leads to complete combustion. And there is a reduction from 80 ppm to 62 ppm was obtained in the B100 pure biodiesel and it is 28%, as compared to diesel at maximum load in NM.

Nitrogen Oxide emissions (NO_x):

The variation of NO_x emission with engine load for different biodiesel blends were tested is shown in Fig-10. The NO_x emission produced from the engine are based on combustion temperature inside the chamber along with the concentration of oxygen content presents in the combustion products. The amount of NO_x emission produced for B100 was found to be 1500 ppm and it was slightly higher when compared to pure diesel fuel about 1200 ppm. From the Fig-10 it was noted that increasing proportion of biodiesel blends was found to be increase NO_x emission sharply, when compared to the pure diesel.

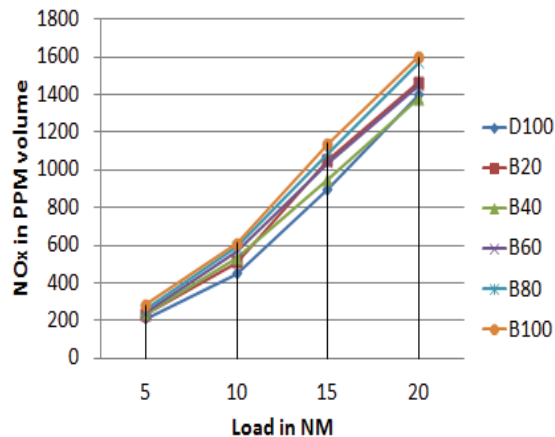


Figure 10. Variation of NO_x emission with Load

V. CONCLUSION

Hence the experiment was carried out in a single cylinder four stroke variable compression ignition engine using various biodiesel blends produced from the chicken fat oil biodiesel and pure diesel successfully. From the results obtained from performance and emission test, the following conclusions are given below:

1. The time requirement for producing biodiesel is about 6 hrs; in that 2 hrs for conducting transesterification reaction and remaining 4 hrs for settle down or separation of glycerol and biodiesel in a reactor.
2. The calorific value of obtained for biodiesel produced from chicken fat oil is 37880 KJ/Kg which is less than the diesel fuel that is 42500 KJ/Kg.
3. The density value for biodiesel was increased about 24%, hence the value for diesel is 840 Kg/m³ and for biodiesel are 885 Kg/m³.
4. Then the brake thermal efficiency (BTE) was found to be 26.15% for B20 blended biodiesel which is more than that the diesel fuel that is 23.67% at maximum load (3.5 KW) condition.
5. From the parameter Break specific fuel consumption (BSFC) the results are , BSFC for blend B20 is 0.3443 Kg/KW-h which is less than the diesel fuel that is 0.3665 Kg/KW-h at maximum load.
6. It can be concluded that the chicken fat oil biodiesel blends with pure diesel fuel have less HC and CO emissions compared with diesel fuel emissions.
7. Hence by the above conclusions the biodiesel produced from the chicken fat oil can be used in place of ordinary diesel fuel in an engine without any modification in an engine.

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