Production of Biodiesel using Waste Cooling Oil

Pradeep H
Assistant Professor
BGSIT, B. G. NAGAR, Nagamangala (Tq.)
Mandya (Dist.)

Sachin A S
UG Scholar, Department of Mechanical Engineering
BGSIT, BG nagar,
Nagamangala (Tq.) Mandya (Dist.)

Chetan Sharanagod Biradar
UG Scholar, Department of Mechanical Engineering
BGSIT, BG nagar, Nagamangala (Tq.) Mandya (Dist.)

Harish K R
UG Scholar, Department of Mechanical Engineering
BGSIT, BG nagar,
Nagamangala (Tq.) Mandya (Dist.)

Pavan Sai K
UG Scholar, Department of Mechanical Engineering
BGSIT, BG nagar, Nagamangala (t) Mandya (d).

Abstract- **Biodiesel is an alternative fuel for diesel engines consisting of the alkyl monoesters of fatty acids from vegetable oils or animal fats. Most of the biodiesel that is currently made uses soybean oil, methanol and an alkaline catalyst. The high value of soybean oil as a food product makes production of a cost–effective fuel very challenging. However, there are large amounts of low–cost oils and fats such as restaurant waste and animal fats that could be converted to biodiesel. The problem with processing these low cost oils and fats is that they often contain large amounts of free fatty acids (FFA) that cannot be converted to biodiesel using an alkaline catalyst. In this study, a technique is described to reduce the free fatty acids content of these feedstocks using an acid–catalyzed pretreatment to esterify the free fatty acids before transesterifying the triglycerides with an alkaline catalyst to complete the reaction. Initial process development was performed with synthetic mixtures containing 20% and 40% free fatty acids, prepared using palmitic acid. Process parameters such as the molar ratio of alcohol, type of alcohol, acid catalyst amount, reaction time, and free fatty acids level were investigated to determine the best strategy for converting the free fatty acids to usable esters. The work showed that the acid level of the high free fatty acids feedstocks could be reduced to less than 1% with a 2–step pretreatment reaction. The reaction mixture was allowed to settle between steps so that the water–containing alcohol phase could be removed. The 2–step pretreatment reaction was demonstrated with actual feedstocks, including yellow grease with 12% free fatty acids and brown grease with 33% free fatty acids. After reducing the acid levels of these feedstocks to less than 1%, the transesterification reaction was completed with an alkaline catalyst to produce fuel–grade biodiesel.**

Keywords: Alternative fuel, Biodiesel, Diesel, High free fatty acid, Rendered animal fat, Waste restaurant oil.

I. INTRODUCTION

Oil crisis and global warming led to the research has been oriented to find suitable alternative fuels to petroleum oil. Now biodiesel was produced from nonedible vegetable oils because the high price of edible vegetable oils, it was becoming enviromentally an alternative fuel to diesel oils

Biodiesel and its blends with diesel fuel are investigated to solve the problem of depletion of fossil fuels and environmental impact. Biodiesel; as an alternative fuel for diesel fuel, is methyl or ethyl esters extracted from vegetable oils or animal fats by transesterification process. A diesel engine test using waste cooking-oil biodiesel fuel was run to investigate engine performance. By adding 20% of waste cooking-oil biodiesel by volume, there were increase in specific fuel consumption and decrease in thermal efficiency for biodiesel blends compared to diesel fuel.

Experimental tests were conducted on a direct injection diesel engine using diesel fuel, biodiesel and their blends to study engine performance parameters under different engine loads at an engine speed of 1500 rpm. Blended biodiesel fuels containing 19.6, 39.4, 59.4 and 79.6% by volume of biodiesel corresponding to 2, 4, 6 and 8% by mass of oxygen in the blended fuel were Vegetable oils caused operational and durability problems when used in diesel engines. These problems are attributed to higher viscosity and lower volatility of vegetable oils. Transesterification was an effective method of reducing vegetable oil viscosity and eliminating operational and durability problems. Waste cooking-oil biodiesel was used in diesel engines at a rated speed of 1500 rpm and different engine loads. Exhaust gas temperatures of biodiesel blends are increased with increasing biodiesel concentration. Performance characteristics of waste cooking-oil biodiesel blends were close to diesel fuel. Waste cooking-oil biodiesel heating value is lower that of diesel fuel by about 15%

Increase of waste cooking-oil biodiesel percentages in dieselbiodiesel blends led to higher exhaust gas temperatures of waste cooking-oil biodiesel blends in the engine fuelled by biodiesel blends. Increase in specific consumptions had been resulted when using biodiesel blends compared to diesel fuel due to the lower heating value of biodiesel and its blends. Also a decrease in the thermal efficiency of biodiesel blends with the increase in percentage of biodiesel. Waste cooking-oil biodiesel blends of B5 and B10 were used in a single cylinder diesel engine and compared to diesel fuel. Biodiesel blends resulted in increase in specific fuel tested. Biodiesel blends were prepared from waste cooking-oil by transesterification process. It was noticed that specific fuel consumptions of biodiesel blends increase than that of diesel fuel, but there was decrease in thermal efficiencies for biodiesel blends compared to diesel fuel. Four tested diesel-biodiesel blends fuels; diesel fuel, waste cooking-oil biodiesel

ISSN: 2278-0181
NCMPC - 2019 Conference Proceedings

(B5), waste cooking-oil biodiesel (B20), and waste cooking-oil biodiesel (B30), were investigated in a diesel engine at different engine loads. Specific fuel consumptions were found higher for biodiesel blends because biodiesel has lower heating value compared to diesel fuel.

Waste cooking-oil biodiesel blends with diesel fuel of 20, 40, 60 and 80% by volume had been tested in a single cylinder, water cooled diesel engine. Exhaust gas temperatures for biodiesel blends were higher compared to diesel fuel. The experimental results proved that lower and medium percentages of waste cooking-oil biodiesel can be substituted for diesel fuel. Chemical and physical properties of waste cooking-oil biodiesel fuel produced by transesterification are near to diesel fuel. Experimental results showed an increase in specific fuel consumption and a reduction in the engine thermal efficiency compared to diesel fuel due to the oxygen content and the lower calorific value of biodiesel compared to diesel fuel.

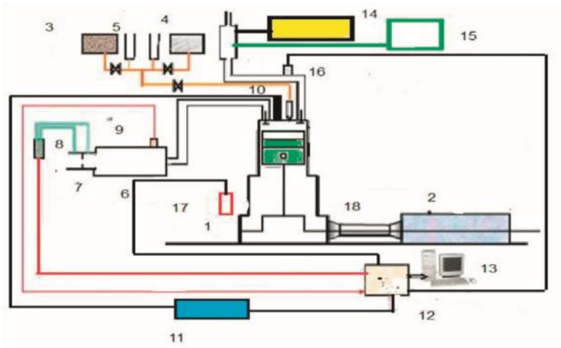
Waste cooking-oil biodiesel was derived from used cooking-oils by transesterification method which used to reduce viscosity of waste cooking-oil. Diesel oil was blended by waste cooking-oil biodiesel with ratio of 25% on volume basis and was tested in a single cylinder diesel engine at different engine loads and rated speed. Specific fuel consumption for blend B25 increased up to 5.69% compared to diesel fuel. Thermal efficiency for blend B25 was lower than that of diesel fuel.

The current work studies the operation of waste cooking-oil biodiesel blends with diesel fuel in diesel engine without any hardware modifications. Transesterification process was used to obtain biodiesel from neat waste cooking-oil. Measured physical and chemical properties of waste cooking-oil biodiesel blends were near to diesel fuel. This study aims to investigate the effect of waste cooking-oil biodiesel blends (B10, B20 and B30) with diesel fuel on performance and exhaust emissions of a diesel engine at different engine loads.. CO, NO_x, HC and smoke emissions were measure and compared to diesel fuel.

II. MATERIALS AND METHODS

A. Biodiesel production process

Waste cooking-oil (waste sunflower oil) was used to produce biodiesel by using trans-esterification method.



1. Diesel engine
2. AC generator
3. Diesel tank
4. Biodiesel tank
5. Burette
6. Air surge tank
7. Orifice
8. Pressure differential meter
9. Intake air temperature thermocouple

10- Piezo pressure transducer
11- Charge amplifier
12- Data acquisition card
13- Personal computer
14- Exhaust gas analyzer
15- Smoke meter
16- Exhaust gas temperature thermocouple
17- Proximity switch
18- Cardan shaft

Fig. 1. Schematic diagram of the experimental setup.

Transesterification method was conducted using a conical equipped with a reflux condenser and thermometer with magnetic stirrer. The flask was charged with waste cooking-oil and preheated to 65 C. Sodium hydroxide (NaOH) 1% by weight of waste cooking oil; as a catalyst was dissolved in methanol solution of 6:1 M ratio methanol to waste cooking oil. Meth-oxide solution was set in a flask for 1.5 h to react. Then mixture was poured into a separating funnel to separate glycerol from biodiesel. Biodiesel is then washed three times, using warm water with 5% acid then with water. The residual methanol, catalyst and water were separated from biodiesel using a rotary evaporator at 80 C. Waste cookingoil biodiesel methyl was dried at 100 C. Biodiesel is mixed with diesel oil at different proportions of 10, 20 and 30% by volume. Density, flash point, Cetane index and calorific value of biodiesel blends were measured as shown in Table 1.

Table 1: Physical and chemical properties of biodiesel blends compared to diesel oil using ASTM standards.

Properties	Method	Diesel oil	B100	B10	B20	B30
Density at 15.56 C kg/m^3	ASTM D-4052	830.3	892.6	856.4	855.8	856.6
Flash point, C	ASTM D-92	72	176	69	60	62
Cetane index	ASTM D-976	60.22	63.63	59.53	60.71	62.11
Calorific value kJ/kg	ASTM D-224	47,108	42,835	47,021	43,953	43,325

B. *Experimental set up*

The experimental run was carried out using a Kirloskar make, single cylinder, four strokes, and direct injection diesel engine with a developing power of 5.775 kW at 1500 rpm at National Research Centre, Engine Research Lab. Fig. 1 illustrates a schematic diagram of the experimental setup. Technical properties of diesel engine are showed in Table 2. Maximum electric power output is 10.5 kW for AC generator is coupled directly to the test engine to determine engine output brake power. The intake airflow was measured by sharp edged orifice mounted on the side of air box to dampen pulsating airflow into engine. A U-tube manometer was used to measure the pressure drop across the orifice. Thermocouple probes of type (K) were used for temperature measurements at different locations in the experimental set up such as intake air manifold and exhaust gas. Two fuel tanks of 5 L capacity were mounted fuelling the engine with diesel and biodiesel fuels. One burette with stopcock and two way valves was mounted for fuel flow measurements and selecting between both diesel and biodiesel fuels. OPA 100 smoke meter and MRU DELTA 1600-V Gas Analyzer were used for the measurements of smoke opacity and exhaust gas concentrations (CO, HC, CO_2 and NO_X). The experiment was carried out by varying engine load from zero to full load maintaining constant rated speed of 1500 rpm throughout the experiment.

Table 2 Engine specification

Engine parameters	Specifications
Type	DEUTZ F1L511
Number of cylinders	1
Number of cycles	Four stroke
Cooling type	Air cooled
Bore (mm)	100
Stroke (mm)	105
Compression ratio	17.5:1
Fuel injection advance angle	24 BTDC
Rated brake power (kW)	5.775 at 1500 rpm
Number of nozzle holes	1
Injector opening pressure (bar)	175

III. RESULTS AND DISCUSSIONS

A. Effect of waste cooking-oil biodiesel blends on CO_2 emissions

Fig. 2 showed the variation of CO_2 emission with engine load for waste cooking-oil biodiesel blends. CO_2 emission is more for biodiesel and its blends than that for diesel fuel. The rising trend of CO_2 emission with engine load was due to the higher fuel entry as the load increased. CO_2 emissions for diesel-biodiesel blends were higher than diesel oil and it is increased with the increase in blend proportion. CO_2 emission increase was due to higher oxygen content in biodiesel blends.

B. Effect of waste cooking-oil biodiesel blends on CO emissions

CO emissions variations with engine brake power are shown in Fig. 3. CO emissions decreased with increasing of engine brake power at lower loads and then increased at higher loads. Decreases in carbon monoxide emission for biodiesel blends were due to more oxygen molecules and lower carbon content in biodiesel blends as compared to diesel fuel which lead to better combustion. The presence of oxygen in waste cooking-oil biodiesel blends is helpful for better combustion and reduction of CO emissions.

3.3. Effect of waste cooking-oil biodiesel blends on NO_x emissions

Variation of NOx emissions for waste cooking-oil biodiesel blends with respect to engine load are shown in Fig. 4. NOx emissions increased with the increase in engine load for all fuels due to increase of fuel burned and the cylinder temperature which is responsible for thermal (or Zeldovich) NO_x formation. Rate of NO_x emissions formation in diesel engines is a function of adiabatic flame temperature which is closely related to the peak cylinder temperature. Higher adiabatic flame temperature, higher cylinder temperature and oxygen content in biodiesel led to higher NO_x emissions. Increase in NO_x emission for waste cooking-oil biodiesel blends was due to increase of oxygen content in biodiesel blends and higher cylinder temperature compared to diesel fuel. NO_x emissions for waste cooking-oil biodiesel blends increased with increase of biodiesel volume percentage.

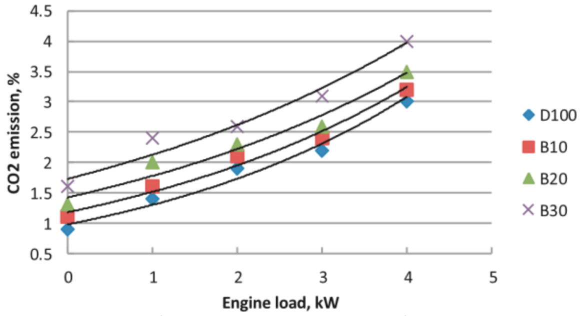


Fig. 2. Variation of CO_2 ratio with engine load for waste cooking-oil biodiesel blends.

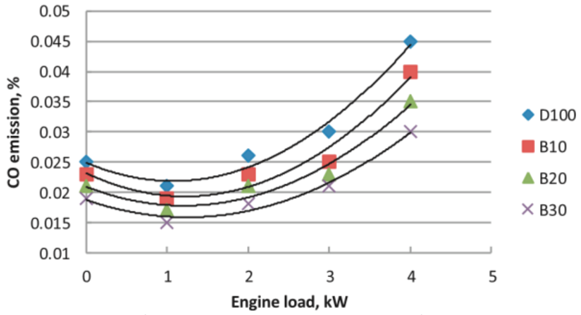


Fig. 3. Variation of CO emission with engine load for waste cooking-oil biodiesel blends.

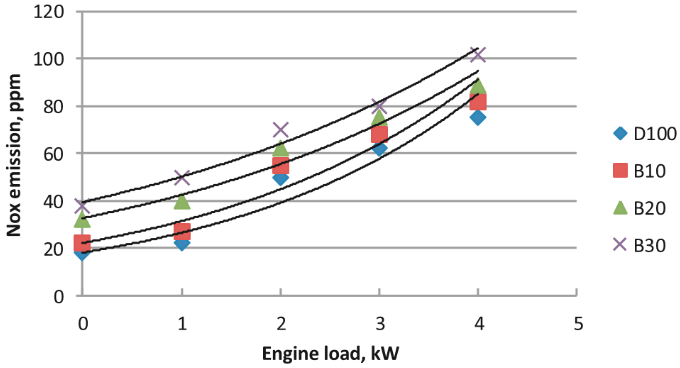


Fig. 4. Variation of NO_x emission with engine load for waste cooking-oil biodiesel blends.

C. *Effect of waste cooking-oil biodiesel blends on HC emissions*

Fig. 5 showed the variation of HC emissions with respect to engine load for waste cooking-oil biodiesel blends. HC emission is lower at engine part load and increases with increase of engine load. This is due to the presence of fuel rich mixture and lack of oxygen resulting from engine operation. Biodiesel blends with diesel fuel produced lower HC emissions at all engine loads compared to diesel fuel. Increase of biodiesel percentage in biodiesel blends led to HC emissions reductions due to the higher Cetane number and oxygen content.

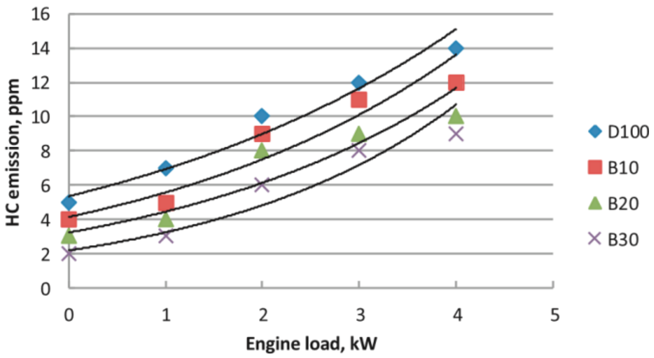


Fig. 5. Variation of HC emission with engine load for waste cooking-oil biodiesel blends

IV. CONCLUSIONS

A single cylinder diesel engine was run using waste cooking-oil biodiesel blends B10, B20 and B30. Performance and exhaust emissions were measured at different engine loads of 1, 2, 3 and 4 kW and a constant engine speed of 1500 rpm. Specific fuel consumption, thermal efficiency, exhaust gas temperature, air-fuel ratio and mechanical efficiency were measured. CO, CO_2, NO_x, HC and the emissions were measured and compared with diesel fuel. The following conclusions could be summarized as:

1. Thermal efficiencies of waste cooking-oil biodiesel blends with diesel fuel were lower compared to diesel fuel and specific fuel consumptions were found to be higher.
2. Higher exhaust gas temperatures were recorded for waste cooking-oil biodiesel blends compared to diesel fuel for the entire engine load. Air-fuel ratios for diesel-biodiesel blends B10, B20 and B30 were lower than diesel fuel.
3. CO, HC and other emissions were lower for waste cooking-oil biodiesel blends compared to diesel fuel.
4. NO_X and CO_2 emissions are increased with the increase of the percentage of biodiesel fuel in the blends.

REFERENCES

[1] R.B. Sharma, Amit Pal, Juhi Sharaf, Production of bio-diesel from waste cooking-oil, J. Eng. Res. Appl. 4 (6) (2013) 1629–1636.
[2] E.M. Shahid, Shah A.N. Jamal, N. Rumzan, M. Munsha, Effect of used cooking-oil methyl ester on compression ignition engine, J. Quality Technol. Manage. VIII (II) (2012) 91–104.
[3] Pedro Felizardo, M. Joana Neiva Correia, Idalina Raposo, Joao F. Mendes, Rui Berkemeier, Joao Moura Bordado, Production, of biodiesel from waste frying oils, Waste Manage. J. 26 (3) (2006) 487–494.
[4] Osmano Souza Valente, Vanya Marcia Duarte Pasa, Carlos Rodrigues Pereira Belchior, Jose Ricardo Sodre, Exhaust emissions from a diesel power generator fuelled by waste cooking-oil biodiesel, Sci. Total Environ. J. 431 (2012) 57–61.
[5] K. Nantha Gopal, Arindam Pal, Sumit Sharma, Charan Samanchi, K. Sathyanarayanan, T. Elango, Investigation of emission and combustion characteristics of a CI engine fueled with waste cooking-oil methyl ester and diesel blends, Alex. Eng. J. 53 (2014) 281–287.
[6] Tushar R. Mohod, Prashant C. Jikar, Vishwanath S. Khobragade, Experimental investigation of a diesel engine fueled with waste cooking-oil ethyl ester, Int. J. Res. Eng. Technol. (IJRET) 2 (5) (2013) 240–244.
[7] C.C. Enweremadu, H.I. Rutto, Combustion, emission and engine performance characteristics of used cooking-oil biodiesel-A review, Renewable Sustainable Energy Rev. 14 (2010) 2863–2873.