Experimental Investigations on Compression Ignition Engine using Mixture of Milk Scum-Niger Seed Oil Methyl Ester as Alternative Fuel

Vijetha Vardhan R N, Girisha H N

Abstract: Biodiesel is made by combining alcohol (usually methanol) with vegetable oil, animal fat, or recycled cooking grease. Among them, much different kind of fuels can be found: bio ethanol, bio butanol, biodiesel, vegetable oils, bio methanol, pyrolysis oils, biogas, and bio hydrogen. This thesis work is focused on the production of biodiesel, which can be used in diesel engines as a substitute for normal diesel. However, vegetable oils are preferred because they tend to be liquid at room temperature, and emit fewer pollutants. This work is carried out with the help of biodiesel made from Niger Seed Oil and Milk Scum Oil with methyl ester which meets the international standards. The performance and emission test were carried out in a single cylinder water cooled direct injection compression ignition engine. The hydrocarbon, carbon oxides and dioxide emissions were found to be less than that of neat diesel fuel except nitrogen oxides. Brake thermal efficiency of biodiesel and its blends was found to be less than diesel fuel. However, exhaust gas temperature, brake specific fuel consumption for biodiesel and its blends were found to be higher than that of diesel fuel.

Keywords: Niger Seed oil; Milk Scum Oil; Emissions; biofuels;

I. INTRODUCTION

Alternative fuel derived from vegetable oil and animal fat have increasingly important due to decreasing petroleum resources and increase in pollution problems.

Biodiesel is a cleaner fuel than petroleum diesel and an exact substitute for existing compression ignition engines. Biodiesel as a biodegradable, sustainable and clean energy has worldwide attracted and growing interest in topical years, chiefly due to development in biodiesel fuel, ecological pressures which include climatic changes, and ability to replace fossil fuels, which are likely to run out within a century. Especially, the environmental issues concerned with the exhaust gases emission by the usage of fossil fuels also encourage the usage of biodiesel, which has proved to be eco friendly far more than fossil fuels and it is renewable in nature. Biodiesel can be used in its pure form or can be blended with diesel to form different blends. It can be used in diesel engines with very little or no engine modifications. This is because it has properties similar to mineral diesel. Biodiesel has several distinct advantages over petro-diesel in that it has higher combustion efficiency, lower sulfur and aromatic content which means it will not emit toxic gases. The major drawback of biodiesel is that it costs much more than petro-diesel when using vegetable oils as feedstock. Therefore, it is necessary to find ways to minimize the production cost of biodiesel. One way is to choose cheaper feed stocks such as dairy waste scum; the other way is to choose a better procedure to reduce the catalyst amount, energy consumption and reaction time.

The search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, management, efficiency and environmental preservation, has become highly pronounced in the present context. Renewable energy technologies fit well into a system that gives due recognition to decentralization, pluralism and local participation. Thermodynamic tests based on engine performance evaluations have established the feasibility of using a variety of alternative fuels such as Compressed Natural Gas, (Ethane, Methane, Propane, Butane, Hydrogen Sulfide), Biogas, Alcohols, Compressed Air, Dimethyle-Ether, Ammonia, Charcoal, Hydrogen, Liquid, nitrogen, LPG or Auto gas, Steam, Wood gas, and vegetable oils. For the developing countries of the world, fuels of bio-origin can provide a feasible solution to the energy crisis. The fuels of bio-origin may be alcohol, vegetable oils or animal fats, biomass and biogas.

Biodiesel is a non petroleum-based fuel defined as fatty acid methyl or ethyl esters derived from vegetable oils or animal fats and it is used in diesel engines and heating systems. Thus, this fuel could be regarded as mineral diesel substitute with the advantage of reducing greenhouse emissions, low emission profile of carbon monoxide and unburned hydro carbon and renewable in nature. Biodiesel production using an alkali catalyst is a common way due to its low temperature and pressure operation. The commercial process is catalytically transesterified by homogeneous acid or base. However, alkali catalyst is quite sensitive to free fatty acid in biodiesel feedstock and thus, expensive pure vegetable oil, which contains free fatty acid of lower than 1 wt. %, is required.

In the case of using vegetable oils with high content of free fatty acid, an esterification process based on acid catalyst can be applied to eliminate free fatty acid before further processing via the conventional transesterification process. However, the high cost of biodiesel is the major obstacle for its commercialization, the biodiesel produced from vegetable oil is usually more expensive than petroleum-based diesel fuel from 10% to 50%.

Revised Version Manuscript Received on November 19, 2016.

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Moreover, during 2009, the prices of virgin vegetable oils have nearly doubled in relation to the early 2000. This is of great concern to biodiesel Producers, since the cost of feedstock comprises approximately 70% to 95% of total operating costs at a biodiesel plant. Compared to neat vegetable oils, the cost of dairy waste scum is anywhere 60% to 80% less to free, because it is a waste generated from dairy industries.

A major hurdle in the commercialization of biodiesel from virgin oil, in comparison to petroleum-based diesel fuel, is its cost of manufacturing, primarily the raw material cost. Dairy waste scum is one of the economical sources for biodiesel production.

Commercial Biodiesel does have standards which must be met, just like commercial petro diesel does. The ASTM Standard for Biodiesel is ASTM D 6751.

II. INTRODUCTION TO OILS

(a) Niger Seed Oil:

Niger (Guizotia abyssinica) is an oilseed crop. It is said to be indigenous to tropical Africa, more specifically to Ethiopia. India is considered to be the chief niger producing country in the world with an area of 5 lakh hectares. It is mainly grown in the states of Madhya Pradesh, Bihar, Maharashtra, Orissa, Karnataka and Tamil Nadu. The niger seed oil is used for human food, medicines and manufacturing a number of industrial products. Its oilcakes are used as cattle feed and leaves add organic matter to the soil.

Guizotia abyssinica is an erect, stout, branched annual herb, grown for its edible oil and seed. Its cultivation originated in the Ethiopian highlands, and has spread to other parts of Ethiopia. Common names include: noog niger, nyger, nyjer, or Niger seed; ramtil orramtilla; inga seed; and blackseed.

(b) Milk Scum Oil:

This scum is collected from the scum removing area of the effluent treatment plant in a fresh condition and processed immediately to avoid increase in free fatty acid further by biological action. Scum is turbid white in color and semi solid in texture.

Annual production of milk in India is 150 million tons per year. Thousands of large dairies are engaged in handling this milk across the country. Raw chilled milk of cows and buffalos are standardized into market milk and milk products such as Butter, Ghee, Cream, Peda, Panner, Cheese, Yoghurt, Ice cream and other products. Large dairies are handling number of equipments for processing, handling, storage, packing and transportation of milk and milk products.

III. ENGINE SETUP AND EXPIREMENTAL PROCUDURE:

Schematic diagram of the engine test rig is shown in Figure 1. The engine test was conducted on four-stroke single cylinder direct injection water cooled compression ignition engine connected to electric type loading. The engine was always operated at a rated speed of 1500 rpm. The engine was having a conventional fuel injection system. The injection nozzle had three holes of 0.3 mm diameter with a spray angle of 120º. It is also provided with temperature sensors for the measurement of jacket water, calorimeter water, and calorimeter exhaust gas inlet and outlet temperatures.

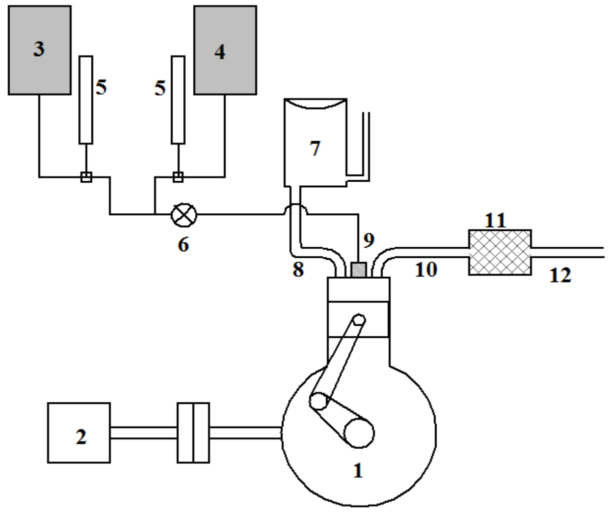

Figure 1 Engine Experimental setup

1). Engine, 2). Alternator, 3). Biodiesel tank, 4). Petrodiesel tank, 5). Burretes, 6). Three way valve, 7). Aix filter with manometer attachment, 8). Inlet manifold, 09). Fuel injector, 10). Exhaust manifold, 11). Smoke meter, 12). Exhaust gas to atmosphere.

Switch on the mains of the control panel and set the supply voltage from servo stabilizer to 220 volts.The main gate valve is opened and the pump is switched ON and the water flow rate to the engine cylinder jacket (300 liters/hour), calorimeter (50 liters/hour), dynamometer and sensors are set. Engine is started by hand cranking and allowed to run for a 20 minutes to reach steady state conditions. The engine soft version 3.0 is run to go on ONLINE mode.

The engine has a compression ratio of 17.5 and a normal speed of 1500 rpm controlled by the governor. An injection pressure of 200 bars is used for the best performance as specified by the manufacturer. The engine is first run with neat diesel at loading conditions such as 25%, 50%, 75% and full load. Between two load trials the engine is allowed to become stable by running it for 3 min before taking the readings. At each loading conditions, performance parameters namely speed, exhaust gas temperature, brake power, peak pressure are measured under steady state conditions.

The experiments are conducted with diesel, methyl esters of dairy waste scum and blends of diesel esters of dairy waste scum; With the above test conditions, the parameters such as TFC, BSFC, BTE are presented with respect to load.

IV. RESULTS AND DISCUSSIONS

(a) Performance Characteristics

The experiments were conducted on a direct injection compression ignition engine with different loads and blends. Analysis of performance parameters and emission characteristics like BSFC, BTE, HC, CO, NO_x and EGT are evaluated. Figure 2 to Figure 8 Results of neat diesel and different biodiesel blends.

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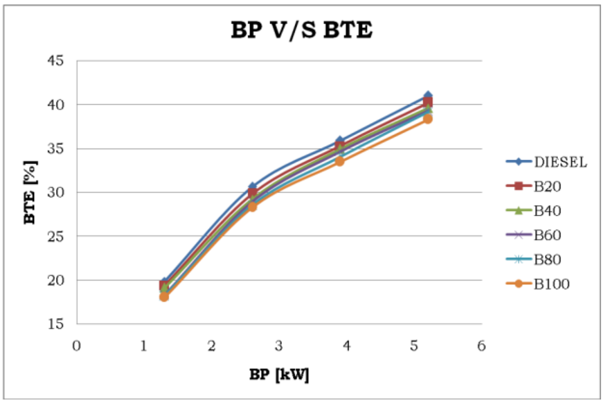

Figure 2 Variation of BP v/s BTE

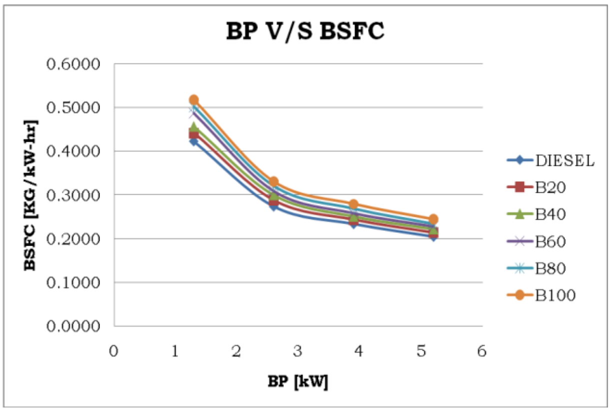

Figure 3 Variation of BP v/s BSFC

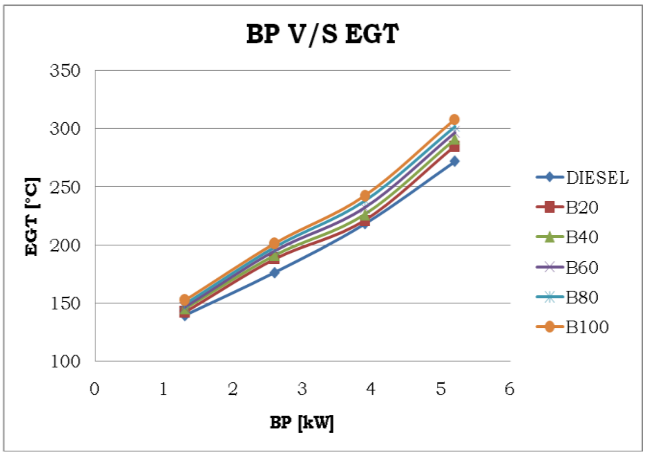

Figure 4 Variation of BP v/s EGT

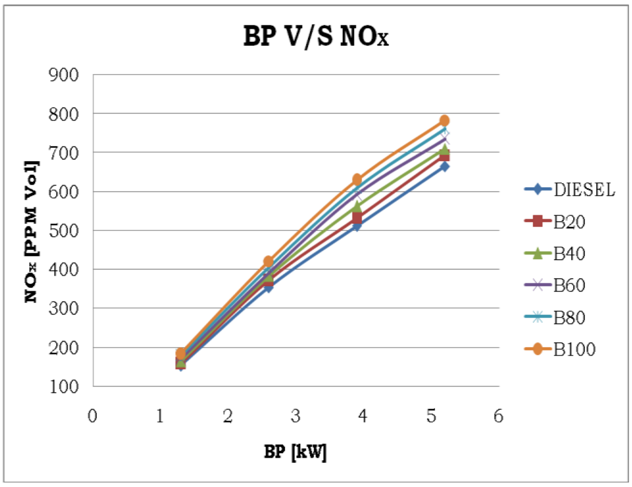

Figure 5 variation of BP v/s No_x

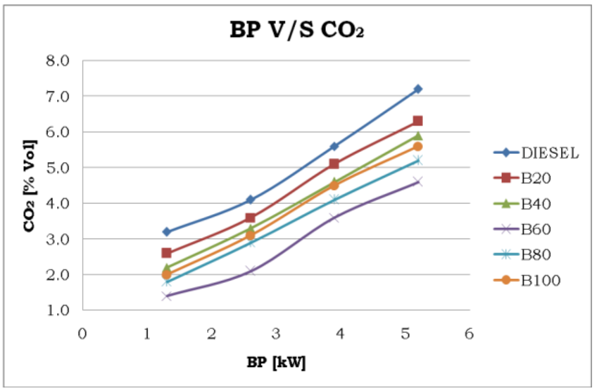

Figure 6 Variation of Bp v/s CO_2

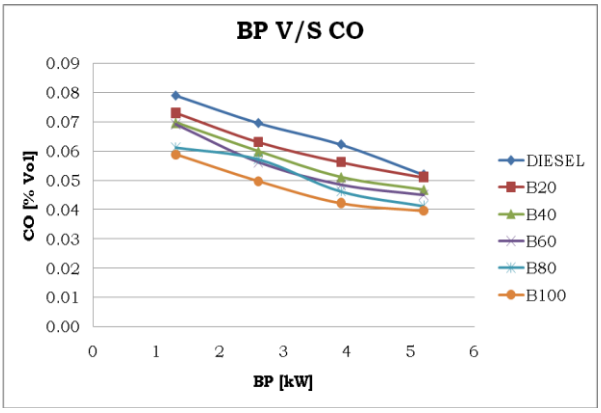

Figure 7 Variation of BP v/s CO

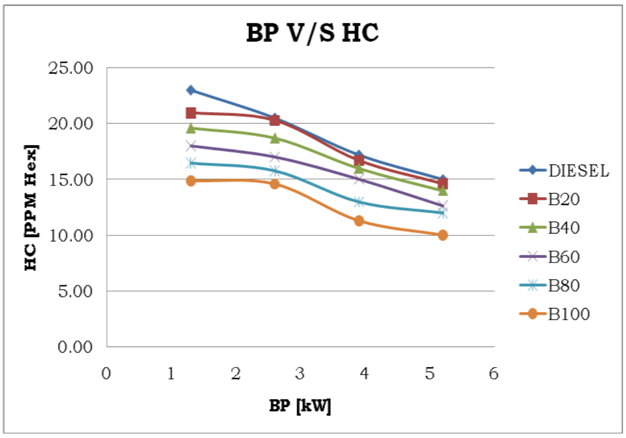

Figure 8 variation of BP v/s HC

(b) General Results

The performance characteristics, brake thermal efficiency, brake specific fuel, Exhaust gas temperature consumption, and emission characteristics, HC, CO, CO_2 and NOx of single cylinder 4-stroke CI at compression ratio of 17.5:1 and injection pressure of 200 bar using mixture NO and MSO biodiesels with their blends as fuels were experimentally investigated. The following general results are made based on the experimental results.

- BTE biodiesel and its blends were found to be less than diesel fuel. The decrease in brake thermal efficiency for higher blends may be due to the combined effect of its lower heating value and increase in fuel consumption and BTE for diesel 41.04% and for B20 blend 40.23% which is 1.97 % lower than the diesel.

Hence B20 blend is more preferable alternative fuel for CI engine.

- The BSFC and EGT increases with the increase of biodiesel in the blends, due to the lower heating value of biodiesel and presence of additional content of oxygen in the biodiesel which leads complete combustion respectively.
- The maximum BSFC at full load is 0.2050 kg/kWh for diesel and for B20 it is 0.2134 kg/kWh which is 3.93% higher than the diesel and The maximum EGT at full load is 272°C for petro diesel for B20 it is 285°C which is 4.56% higher than the diesel. Lesser values of BSFC and EGT are apparently desirable.
- The NOx emission for biodiesel and its blends is higher than that of diesel. This could due to increase in exhaust gas temperature and NOx for diesel 665 ppm and for B20 blend 694 ppm which is 4.17% higher than the diesel. Lesser values of NOx are apparently desirable.
- CO and CO_2 emissions were found to be less than that of neat diesel fuel. CO is one of the compounds formed during the intermediate combustion stages of hydrocarbon fuels. As combustion proceeds to completion, oxidation of CO to CO_2 occurs through recombination reaction between CO and the different oxidants. If these recombination reactions are incomplete due to lack of oxidants or due low gas temperature, CO will exist. CO and CO_2 values for B20 as compared to pure diesel are decrease by 12.5% and 1.73% respectively.
- The HC emission for biodiesel and its blends is lower than that of diesel. Unburnt hydro carbons emission is the direct result of incomplete combustion. At full load condition emission of HC is 2.67% lower than the diesel.

V. CONCLUSIONS

Alternative fuel derived from vegetable oil and animal fat have increasingly important due to decreasing petroleum resources and increase in pollution

In the present work the biodiesel is produced using NO and MSO and performance evaluation of single cylinder four stroke DI diesel engine using neat diesel.

- The parameters affecting the transesterification process such as alcohol to oil molar ratio, catalyst amount, reaction temperature and reaction time are analyzed.
- The measured important properties of produced methyl ester (kinematic viscosity, flash point, and acid value) met the IS 15067, ASTM D6751 and EN 14214 biodiesel standards.
- Brake thermal efficiency blends are slightly less than that of diesel. Compared to Petro diesel at higher load, the BTE of B20 is decreased by 1.97% at full load.
- Brake specific fuel consumption of biodiesel blends is slightly more than that of diesel. Compared to Petro diesel at full load, the BSFC of B20 is increased by 3.93% at full Load.
- Exhaust gas temperature of B20 is closed to that of Petro diesel.
- NO_x emission for B20 is slightly higher than that of petro diesel.
- Emission of CO and CO_2 was considerably reduced as the load increased for biodiesels compared to Petro diesel.
- Hydro carbon emission for B20 is 2.67% less than that of Petro diesel.

Table 1 Technical Specification of Engine

Engine details	**4 stroke, constant speed, water cooled, Direct injection compression ignition engine**
Make model	Kirlosker AV- I
Number of cylinder	One
Rated power	5.2Kw
Speed	1500 rpm
Bore	87.5 mm
Stroke	110mm
Connecting rod length	234mm
Compression ratio	17.5
Swept volume	661 CC
Dynamometer	Eddy current
Dynamometer arm length	195mm
Injection pressure	200 bar
Load measurement	Electrical loading
Temperature indicator	Digital, PT-100 type temperature sensor
Air box	With orifice meter (C_d = 0.6) and manometer
Fuel tank	6 liter capacity with graduated glass fuel metering column

REFERENCES

1. Su Han park, In mo Youn, Chang Sik Lee, “Influence of ethanol blends on the combustion performance and exhaust emission characteristics of a four-cylinder diesel engine at various engine loads and injection timings” Fuel 90 (2011) 748–755.
2. Fengxian Qiu , Yihuai Li, Dongya Yang , Xiaohua Li , Ping Sun “Biodiesel production from mixed soybean oil and rapeseed oil” Applied Energy 88 (2011) 2050–2055
3. Mario l. Randazzo, José r. Sodré, “exhaust emissions from a diesel powered vehicle fuelled by soybean biodiesel blends (B3–B20) with ethanol as an additive (B20E2–B20E5)” Fuel 90 (2011) 98–103
4. Geyer SM, Jacobus MJ, Huseyin aydin. Comparison of diesel engine performance and emission from Neal and transesterfied vegetable oils ASAE 1984; 27 (2):375-84
5. Gupta, P.K. 1994. Investigations on methyl ester of plant oils as alternate renewable fuel for compression ignition engines. Thesis, Ph.D. Punjab Agricultural University, Ludhiana, India.
6. Deepak Agarwal, Shailendra Sinha, Avinash Kumar Agarwal, “Experimental investigation of control of NOx emissions in biodiesel fuelled compression ignition engine”, Renewable energy 31(2006)2356-2369.
7. Gvnsr Ratnakara Rao, V.Ramachanra Raju And M.Muralidara Rao, “Optimizing the compression ratio for a Mahua fuelled C I. engine”, ARPN journal of engineering and applied sciences, Volume4, no: 3 May 2009.
8. Sukumar Puhan, N.Vedaraman, Boppana V.B. Ram, G.Sankaranarayanan, Kjayachanderan, “Mahua oil methyl ester as biodiesel preparation and emission characteristics”, Biomass & Bio energy 28(2005) 87-93.
9. Sharanappa Godiganur, C.H. Suryanarayana Murthy, Rana Prathap Reddy,"6BTA 5.9 G2-1 Cummins engine performance and emission tests using methyl ester mahua (Madhuca indica) oil/diesel blends”, Renewable energy 34(2009)2172-2177
10. L C Meher, S N Naik and L M Das, Methanolysis of Pongamia pinnata (karanja) oil for production of biodiesel, Journal of Scientific & Industrial Research Vol. 63, November 2004, pp 913-918.
11. Venkateswara Rao T, Prabhakar Rao G, Hema Chandra Reddy K., 'Experimental Investigation of Pongamia, jatropha and neem methyl esters as biodiesel on C.I. Engine. Jordan J Mech Indus Eng 2008; 2(6665):117–22.