Effect Of Injection Opening Pressure On Ci Engine Using Calophyllum As Bio-Fuel

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Abstract

Overdependence on the non-renewable petroleum products is the reason for world to consider alternative fuels to replace diesel fuel. Different economic sectors consume various percentages of petroleum products. Using petroleum products ends up with CO, UHC, NOx, smoke, etc as pollutants. Alternative fuels such as vegetable oils are among the few having their properties being close to diesel fuel except for the disadvantages like high viscosity and low volatility. In this project work, experiments are conducted on 3.7 kW(5 BHP) single cylinder, four stroke, water-cooled diesel engine using calophyllum oil methyl esters blended with diesel in various proportions to study the engine performance and emissions at different injection pressures. The injection pressure was changed by adjusting the fuel injector spring tension. The effect of injection pressure on the performance and emission characteristics for various biodiesel blends of C10, C20 and C30 at three different test pressures of 200, 210 and 220 bar are studied. The performance and emission characteristics are presented graphically and concluded that at 220bar injector opening pressure C20 blend is giving higher brake thermal efficiency than diesel with less CO and HC emissions with increase in Nox than diesel.

Key words: D.I. Diesel engine, calophyllum oil methyl esters blends, Injection Opening Pressures.

I. INTRODUCTION

An alternative fuel for internal combustion (IC) engines is considered as a viable option because of the pollution effect & amount of petroleum products available. As an alternative fuel is biodegradable and renewable fuel, biofuel is the most suited substitute for biodiesel. In developing countries the demand for petroleum products are increasing day by day hence there is a need to find out an appropriate solution.

Biodiesel like jatropha, karanja, pongamia, simarouba glauca, and surahonne oils are available in abundance, which can be converted to biodiesel. The use of vegetable oils, such as palm, soya bean, sunflower, peanut and olive oil as alternative fuels for diesel is being promoted in many countries. Both these plants may be grown on a massive scale on agricultural/degraded/waste lands, so that the chief resource may be available to produce biodiesel on farm scale. The performance and emission characteristics of these bio-diesel blends with diesel have been studied. Tests were carried out for analyzing various parameters such as thermal efficiency, brake specific fuel consumption (BSFC), emission of CO, HC and NOx gases in exhaust. Experiments were carried out with biodiesel on direct injection diesel engine and it was reported that performance was almost similar with pure diesel operation on conventional engine.

The idea of using bio-fuels for Direct Injection Compression Ignition Engine is not new. It dates back to early nineteenth century; Rudolph Diesel had tested his diesel engine with peanut oil at Paris Exposition of 1900. In spite of the technical feasibility, the bio-fuels were unable to get wide acceptance in the engineering world as its manufacturing was more expensive than conventional petroleum and the environmental aspects were out of concern.

II. BIO-DIESEL PREPARATION
Production of Calophyllum Inophyllum Oil
The production of Calophyllum inophyllum oil was carried out in the following order.

Drying: The seeds collected were made to dry under hot sun, causing the inner seeds to detach from the outer shell.

Shelling: The shelling process is to remove the seed coat of the calophyllum inophyllum seeds. It was carried out manually.

Milling: The unshelled seeds were milled into dough by using the corn milling machine.

Determining Moisture Content: The moisture content was determined and was found to be more than 12 percentages by Karl Fischer titration method. The water was to be removed to achieve 12% moisture content.

Heating: Heating of the seeds was done in an oven. The temperature was raised to 80-850C, so as to remove the moisture content completely. The heated dough is thus free from moisture.

Pressing: Pressing was done by using an Oil press and the Calophyllum inophyllum oil was extracted from the dough and taken for filtration.

Filtration: The oil was collected and filtered using coarse and fine filters. Thus removing the finest dust and slag particles left over the pressing process.

Production of Calophyllum Inophyllum Bio-Diesel

Pretreatment: Filtered Calophyllum oil if first taken to remove moisture. As water content of the feedstock is critical parameter and should be kept below 0.06% w/w for better conversion of oil to esters. Hence the raw oil is kept in an oven at 105°C for 2-3hrs to remove the water content from the oil. After demoisture, detoxification with 1% hydrochloric acid (HCL) is carried out. The parameters present in trace quantity like carbon residue, unsaponifiable material and fiber etc. are removed. The oil was the processed for property tested. The free fatty acid content of raw oil and products after reactions were determined by standard titrimetry methods (ASTM-664). The fatty acid composition of calophyllum inophyllum oil was obtained from gas chromatography-flame ionization detector (GC-FID).

Esterification: Calophyllum oil contains 19.58% free fatty acids. The methyl ester is produced by chemically reacting Calophyllum oil with an alcohol (methyl), in the presence of catalyst. A two stage process is used for the transesterification of Calophyllum oil. The first stage (acid catalyzed) of the process is to reduce the free fatty acids (FFA) content in Calophyllum oil by esterification with methanol (99% pure) and acid catalyst sulfuric acid (98% pure) in one hour time at 57°C in a closed reactor vessel. The Calophyllum oil is first heated to 50°C then 0.7% (by wt. of oil) sulfuric acid is to be added to oil and methyl alcohol about 1:6 molar ratio (by molar mass of oil) is added. Methyl alcohol is added in excess amount to speed up the reaction. This reaction was proceeding with stirring at 650rpm and temperature was controlled at 55-57°C for 90 min with regular analysis of FFA every after 25-30 min. When the FFA is reduced up to 1%, the reaction is stopped. The major obstacle to acid catalyzed esterification for FFA is the water formation. Water can prevent the conversion reaction of FFA to esters from going to completion24. To achieve acceptable percentage of FFA, we performed this stage two times. After dewatering the esterified oil is fed to the transesterification process.

Transesterification: The bottom layer product of acid esterification was heated to the desired temperature before starting the reaction. The potassium hydroxide–methanol solution was prepared. The alkali methoxide solution was added to preheated product of the acid esterification while mixing by means of a mechanical stirrer fixed in the transesterification flask. The product was allowed to settle under gravity for 8 hours in a separating funnel. The products of the alkali transesterification process result in the formation of two layers viz., an upper layer containing a mixture of small quantities of unreacted oil, glycerol and transesterified products (esters) and a lower layer of glycerol. The lower layer of glycerol was then removed.

Post Treatment: The upper layer of alkali transesterification product was mixed with petroleum ether. The esters and un-reacted oil readily mixed into the petroleum ether with glycerol as a separate layer. The separated layer was also removed. The upper layer was a mixture of esters and un-reacted oil. These two were separated by diluting the mixture with fresh and sufficient quantity of methanol. The esters went into the methanol and un-reacted oil remained as a
separate layer. The lower layer of un-reacted oil was removed. The upper layer was heated to 65°C to remove methanol. The product was Calophyllum oil methyl ester (COME), a biodiesel. The COME was mixed gently with distilled water (30% of volume of distilled water to volume of biodiesel) at 60°C in order to remove impurities like catalysts. The mixture was allowed to settle under gravity for 8 hours. The settled layer of mixture with impurities was drained out. Water wash was repeated till the pH value of drained water was nearly same as that of distilled water before water wash. The water wash was done to increase the purity of the product by removing the finest dust particles and other impurities. After washing, the final product was again heated to 110°C for 10 min to remove moisture.

III. EXPERIMENTAL SET UP

A single cylinder 4-stroke water-cooled diesel engine having 5 hp as rated power at 1500 rpm was used for the project work. The engine was coupled to a mechanical dynamometer for loading. A speed sensor along with a digital rpm indicator was used to measure the speed of the engine. The fuel flow rate was measured on volumetric basis, thermo couples were used for measuring the cooling water and exhaust gas temperatures. The experimental set-up of the engine is shown in the fig. 5.1. The experiments are conducted at constant speed and at four different loads levels viz., 20%, 40%, 60% and 80% full load. The required engine load percentage is adjusted by using the mechanical dynamometer (rope brake dynamometer) for diesel fuel and the readings are tabulated. The same procedure is carried out for biodiesel blends (C10, C20 & C30).

The engine has a compression ratio of 16.5 and a normal rated speed of 1500 rpm controlled by the governor. An injection pressure of 210 bar is used for the best performance as specified by the manufacturer. The engine is first run with diesel at loading conditions such as 20%, 40%, 60% and 80%. Between two load trials the engine is allowed to become stable by running it for 3 minutes before taking the readings. At each loading conditions, performance parameters namely speed, exhaust gas temperature, fuel flow rate and manometer readings are measured under steady state conditions. The experiments are repeated for various load conditions. With the above experimental results, the parameters such as brake power, total fuel consumption, brake specific fuel consumption, brake mean effective pressure, brake specific energy consumption, brake thermal efficiency, indicated power, indicated thermal efficiency and mechanical efficiencies are calculated. Finally the graphs are plotted for total fuel consumption, brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature, and emission results are plotted with respect to brake power for diesel and bio-diesel blends.

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IV. RESULTS AND DISCUSSIONS

BP v/s BSFC for different injection pressures

From the above graphs we can say that BSFC for C20 blend is 7% less compared to diesel and other blends in 220bar IOP but in 200, 210bar IOP the BSFC of bio-diesel are high compared to diesel.

BP v/s $\eta_{bt}$ for different injection pressures

From the above graphs we can say that brake thermal efficiency of C20 blend is 20.7% higher than diesel in 220bar IOP but in 200, 210bar IOP diesel fuel is having better brake thermal efficiency compared to bio-diesel blends.

BP v/s EGT for different injection pressures

From the above graphs we can see that EGT of C20 blend is 43° less compared to diesel and other bio-diesel blends in 220bar IOP. But in 210bar EGT of bio-diesel blends C20, C30 are high Compared C10 and diesel, in case of 200bar EGT of bio-diesel are similar to diesel.

BP v/s CO for different injection pressures

From the above graphs we can see that the emission of CO is less in case of all IOP and C20 blend is
showing better result in all IOP. CO is 7% less compared to diesel in 220bar.

BP v/s No for different injection pressures

From the above graphs we can say that at 60% lodging the emission No is more in C10 in all IOP but in 220bar the emission of NO is almost equal to diesel in C20 blend.

BP v/s HC for different injection pressures

From the above graphs we can see that the liberation of HC from bio-diesel is less compared to diesel in 200, 210bar IOP. But in 220bar there is no significant change in HC emission.

V. CONCLUSION

The project work is carried out to know the effect of injection of opening pressure on 3.7 kW(5 BHP) single cylinder, four stroke, water-cooled diesel engine using calophyllum oil methyl esters blended with diesel in various proportions. The performance and emission characteristics are measured at 60% of full load for C20 calophyllum oil methyl ester blend. The following results were obtained.

1. The BSFC calophyllum oil methyl ester C20 blend when compared with diesel is 4% high at 200bar, 15.4% high at 210bar and 7% high at 220bar.

2. At 220bar IOP brake thermal efficiency for C20 blend is 20.7% & for diesel it is 18.9%, i.e. approximately 10% higher than diesel.

3. The CO emissions of calophyllum oil methyl ester blends are less in all IOP compared to diesel.

4. The HC emissions of calophyllum oil methyl ester for the 3 blends are less in all IOP compared to diesel. HC emission of C20 is 12.9%, 10% & 6% lower than diesel at 200bar, 210bar & 220bar respectively.

5. The liberation of Nox is high in calophyllum oil methyl ester blends compared to diesel, i.e. 29.2% high in 200bar, 23.2% high in 210bar and almost same in 220bar.

Fuel economy is important for engine. But environmental protection is more important than fuel economy. So, decreasing emission is the primary concern for CI engine, the brake thermal efficiency of calophyllum oil methyl ester blend C20 is high compared to diesel in 220bar injection opening pressure with better emission results. So use of calophyllum oil methyl ester C20 blend as a bio-fuel in IC engines at 220bar IOP is recommended.
REFERENCES


