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Experimental Investigations on LHR Diesel Engine Using Biodiesel with Nano Additive

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Abstract: Fossil fuels, including coal, oil and natural gases are currently the worlds primary energy sources, which are depleting now a days. Due to this reason biodiesel fuels is introduced as an alternative fuel. The drawbacks in using biodiesel as a substitute fuel to diesel, in the properties associated with biodiesel are inferior. Hence in order to overcome these problems, certain properties to be improved. To establish the performance, emissions and combustion characteristics of LHR diesel engine with varied combustion chambers by using Neem biodiesel (Bl00) and calcium carbonate Nano fluid additives . In order to study the characteristics of combustion, Suitable combustion chamber design modifications are required to meet emission norms and also acceptable engine performance. Two combustion chamber shapes are selected viz.. Torodial combustion chamber and hemispherical combustion chamber for controlling combustion process, emissions and performance parameters. In this work Neem biodiesel is used as an alternative fuel, where pure neem biodiesel leads to reduction in, HC and CO emissions but increase in fuel consumption and NO_x emissions on diesel engine without any modification. To increase the brake thermal efficiency and to decrease the NO_x emissions nano particle calcium carbonate is added to the neem biodiesel. The $CaCO_3$ additive is added in the biodiesel at appropriate two proportions (i .e 5gm/L and 3gm/L). The experiments are carried out on single cylinder, four stroke, LHR diesel engine connected to eddy current dynamometer. Performance and emission characteristics are computed. Emissions like CO, NO_x, HC, O_2 and CO_2 are evaluated by using five gas analyzer. The results shows that with TCC the emissions about 30% are decreased when compared to other combustion chambers at full load operation. The reason is that with TCC process the fuel was burnt completely by the swirl effect.

Keywords: Neem biodiesel, LHR, $Caco_3$ nano fluid additive, combustion chambers.

1. Introduction

If we estimate on usage of diesel engines are increasing now a days in a rapid manner due to its significant performance, Environmental benefits and better fuel economy when compared with gasoline engines. In order to replace diesel fuel with an alternative fuel Neem biodiesel (B100) is used. Biodiesel is a liquid fuel often referred to as B100 or neat biodiesel in its pure, unblended form. Pure 100% Neem biodiesel will increase the fuel consumption and emissions that are evaluated from diesel engine. The main reason to select a biodiesel as an alternative fuel is that it can be produced from renewable resources, can be used in any existing diesel engines without any modifications of engine and also less green house gas emissions. The main advantage of a biodiesel is that it can be described as a carbon neutral, biodegradable and non toxic.

Analysis of performance and emission on compression ignition engine fuelled with blends of Neem biodiesel. They concluded that s lower emissions and higher performance for B10 than the other blends and diesel. The brake thermal efficiency is higher than the diesel and CO, HC and NOX emissions were 23%, 8.5%, and 22% lesser than that of diesel [1].

Production of bio-fuel from crude neem oil and its performance. They observed that At 200 and 220 injection pressure, neem blends has almost same BSFC as diesel. N20 has high BSFC at low load. At 200 bar injection pressure diesel had highest peak pressure followed by B30, B20 and B10 this trend remain same as the load increases. Among all blends cylinder pressure of B20 and B30 were almost same as diesel at all loads [2].

Performance and Emission Characteristics of Diesel Engine Fuelled with Neem Oil Methyl Ester Blends. They found that BTE of C.I engine using NOME blend B20, B30 and diesel are 28.32%, 27.69% and 26.74% respectively at full load condition, the efficiency with B20 blend is higher as compared to B30 and diesel. Exhaust emissions, especially carbon monoxide (CO), hydro carbon (HC) are decreased with NOME blends as compared to diesel. NOx emissions for B20 and B30 are higher as compared to diesel. The values of NOx emissions are 150 ppm and 60 ppm higher than the diesel for B20 and B30 respectively. In comparison with diesel, the smoke emissions from B20 and B30 are lesser by about 5.1% and 8.1% respectively at full load [3].

Combustion, performance and emission characteristics of diesel engine with neem oil methyl ester and its diesel blends. They reported that The BTE and BSFC for 20,40 and 100% NOME are lower than that of diesel fuel at full load. From the emission analysis it is observed that there is a 10, 15 and 20% increase in NO emission for 20, 40 and 100% NOME at full load as compared to diesel fuel. The CO emissions are lowered by 23, 30 and 40% for 20, 40 and 100% NOME at full load as compared to diesel fuel. The HC emissions from 20, 40 and 100% NOME blends are increased as compared to that of diesel [4].

Researchers are also attempting to find different techniques of efficient fuel utilization in diesel engines. Conducted experiment on effect of combustion chamber shapes and EGR on the performance of biodiesel fuel engines and results are shown Brake thermal efficiency of toroidal is more than other two due to swirl effect Increase in EGR also increases the emission of CO, CO2, smoke opacity for the same reason (burnt gases recirculated) [5].

2. Experimental Procedure

The Neem oil which is brought from plant is crude oil and by selecting one of the most popular method of transesterification process the Neem crude oil is converted in to Neem biodiesel as shown below.

Steps:

- Initially Neem crude oil is heated up to 65 degrees.
- The alkali catalyst sodium hydroxide (NaoH) that is 8gm/L is used for transesterification process.
- Ethanol of 200 ml for 1 liter is used on a certain proportion base. Then with the help of stirrer of 450rpm stir the mixture about 1hour to get a ethyl esters and glycerol.
- After stirring process left the crude oil for 24 hours then a successful transesterification reaction is signified by the separation of the methyl ester (biodiesel) and glycerol layers after the reaction time
- The layer of methyl ester (which is formed as a top layer) that is in the form of Neem biodiesel is used as a fuel in diesel engine.

Fig 2.1 Transesterification process

In the pure Neem biodiesel (B100) 3gm/l and in one more proportion 5gm/l of $caco_3$ is added and stirred for half-hour to make Neem biodiesel blends.

2.1 Nano Fluid Additives

In this process followed a two step method where direct mixing of base fluid with the nano material. In the first step we get nano materials which are synthesized & obtained as powders which are then introduced to a base fluid (Neem biodiesel) in the second step.

2.2 Calculated Properties of Neem Biodiesel and Its Blends With Additives

Parameters	Neem crude oil	(B100) Pure Neem	B100 + 3gm/l $Caco_3$	B100 + 5gm/l $Caco_3$	Diesel
Density Kg/m^3	960	948	940	930	830
Kinematic Viscosity cSt	27.32	13.05	9.50	11.51	4
Flash Pt Deg C	250	175	120	95	52
Calorific Value MJ/Kg	32	35	40	42	42

Cetane number	31-51	48-53	56	68	47

Table 2.2 properties of neem and its blends

3. Experimental Setup

A single cylinder four strokes, naturally aspirated, direct injection and water cooled LHR Engine with a displacement volume of 661 cc, compression ratio (CR) of 17.5:1 and rated power output of 5.2 kW at 1500 rpm is used for conducting experiments. The Engine run at its rated speed of 1500 rev/min. Engine is directly coupled to an eddy current dynamometer that permit Engine motoring either fully or partially. The Engine and the dynamometer are interfaced to a control panel. The Engine run at its rated speed of 1500 rev/min. Engine is directly coupled to an eddy current dynamometer that permit Engine motoring either fully or partially. The Engine and the dynamometer are interfaced to a control panel. Lab view based Engine Performance Analysis software package "Engine softLV" is provided for on line performance evaluation. A computerized Diesel injection pressure measurement is optionally provided.

Fig 3.1 Experimental Engine

The analyzer works on the principle of selective absorption of the infrared energy of a particular wavelength peculiar to a certain gas, which will be absorbed by that gas. In this research work Mars gas analyzer is used to find carbon monoxide (CO), carbon dioxide (CO_2), oxygen (O_2), hydrocarbons (HC) and oxides of nitrogen (NOx) from exhaust.

Fig 3.2 Exhaust Gas Analyzer

3.1 Combustion Chambers Used:

Direct Injection Chambers – Open CC

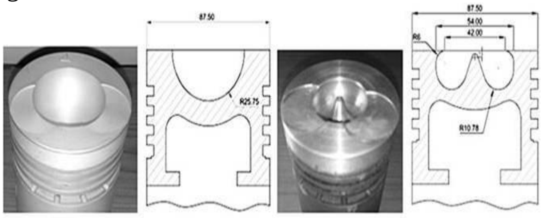
An open combustion chamber is defined as one in which the combustion space is essentially a single cavity with little restriction from one part of the chamber to the other and hence with no large difference in pressure between parts of the chamber during the combustion process.

Hemispherical chamber:

Hemispherical chamber also gives small squish. However, the depth to diameter ratio for a cylindrical chamber can be varied to give any desired squish to give better performance.

Toroidal Chamber:

The idea behind this shape is to provide a powerful squish along with the air movement, similar to that of the familiar smoke ring, within the toroidal chamber.



Hemispherical Open Combustion Chamber (HCC) Toroidal Re-entrant Combustion Chamber (TRCC)

Fig.3.3 line diagrams of HCC and TCC

Due to powerful squish the mask needed on inlet valve is small and there is better utilization of oxygen. The cone angle of spray for this type of chamber is 150° to 160°.

3.2 Experimental Procedure

All the tests were conducted for single cylinder four stroke water cooled direct injection with eddy current dynamometer diesel engine at the rated speed of 1500 rpm. The tests were conducted on diesel engine using diesel, Neem biodiesel (B100), Neem biodiesel with 3gm $CaCO_3$ nano fluid additive and 5gm of $CaCO_3$ by varying combustion chambers of TCC and HCC are used the performance and combustion characteristic are recorded by varying load

4. Results and Discussion

Initially tests were conducted with diesel at the rated speed and variable load conditions, the load on the engine was gradually increased by rotating dynamometer loading unit, and then with pure neem biodiesel and neem biodiesel blends with two combustion chambers i.e HCC and TCC are done.To compare the performance parameters like BP, mechanical efficiency, BSFC and BTE. The emission parameters that are evaluated are CO, HC, CO_2, O_2 and NO_X and compared with the values of blends with combustion chambers.

4.1. Break Specific Fuel consumption vs Brake Power

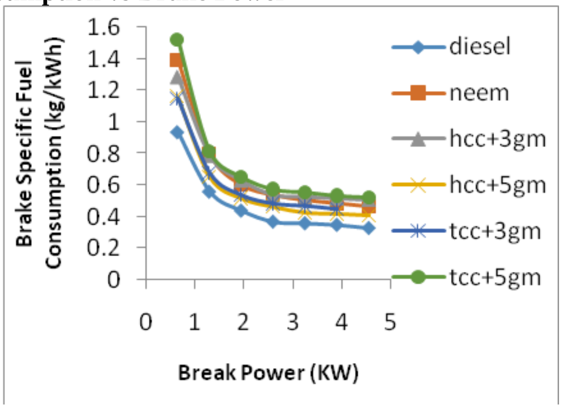


Fig: 4.1 BSFC Vs Brake Power

Increasing brake power fuel consumption was decreased. At higher load conditions it is observed that the BSFC is less for HCC with 5gm neem oil is preferable other than diesel fuel when compared to Neem biodiesel (B100) and its blends because of lower brake thermal efficiency value.

4.2.Brake Thermal Efficiency (η_{bth}) vs Brake Power

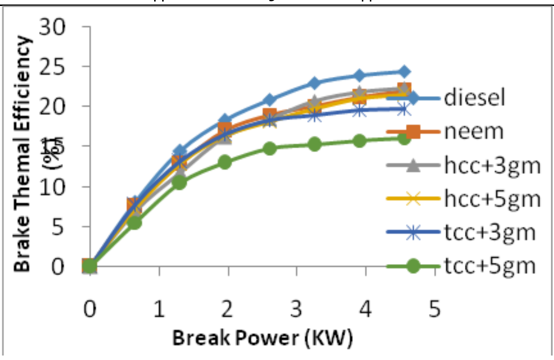


Fig: 4.2 BTE Vs Brake Power

From the fig 4.2 it is observed that BTE increases with the increase in load for all the fuels. The use of Biodiesel blends was useful due to more heating value and high viscosity of biodiesel blends compared to diesel. The BTE is almost same for diesel and Neem biodiesel. Whereas the BTE Neem biodiesel +3gm/l (caco3) + Hcc is more because of lower calorific value and total fuel consumption. BTE for 3gm is more than that of Neem biodiesel (B100) and 5gm $caco_3$.

4.3. Mechanical Efficiency (η_m) vs Brake Power

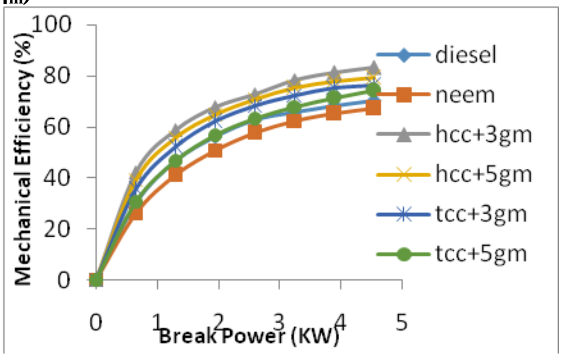


Fig: 4.3 Mech. Efficiency Vs Brake Power

From the fig 4.3 it is found that Mechanical efficiency is maximum for Neem biodiesel added 3gm/l caco3 with hcc when it is compared to diesel. At all load conditions mechanical efficiency is more due to less frictional power.

4.4. Oxides of Nitrogen vs Brake Power

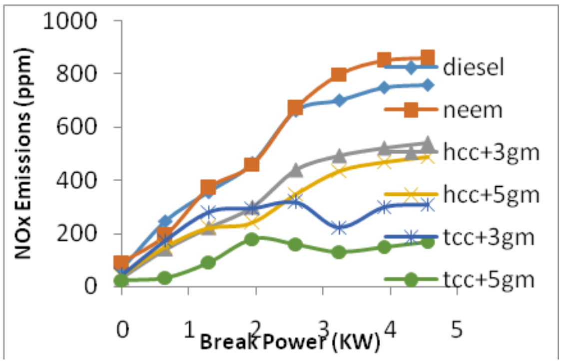


Fig: 4.4 Nox Emission Vs Brake Power

From the fig 4.4 it is concluded that NO_x levels are higher for biodiesel compared to diesel operation. Since the biodiesel molecule contains oxygen in its structure, the amount of oxidizer required by the engine gets reduced. By adding calcium carbonate, there is reduction in NO_X emission. This is because calcium carbonate 48% of oxygen acts as an oxygen buffer and donates surface lattice oxygen. It was observed that Neem bio diesel with 5gm/l blends +tcc has less NO_X formation than diesel at higher loads.

By using toroidal combustion chamber the maximum oxides nitrogen gases will burn, so to reduce Nox emission tcc is used.

4.5. CO Emissions Vs Brake Power

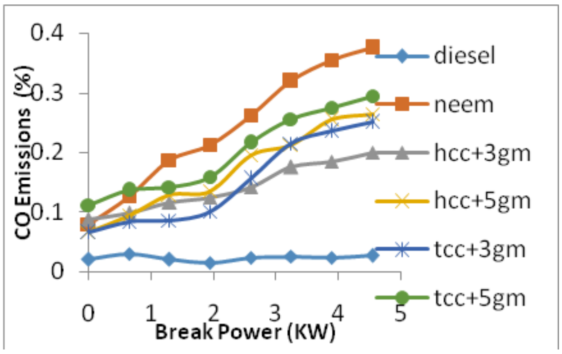


Fig: 4.5 CO Emissions Vs Brake Power

CO is an intermediate combustion product and is predominantly formed due to the lack of oxygen and incomplete combustion. If combustion is complete CO will be converted to CO_2. CO are found to be considerably reduced on the addition of the calcium carbonate additive of 3gm/l with hemispherical combustion chamber where complete burning of fuel taken place due the reason that un burnt particles for blends of 3gm are lower when it is compared to other fuels.

4.6 Carbon Dioxide Emission Vs Brake Power

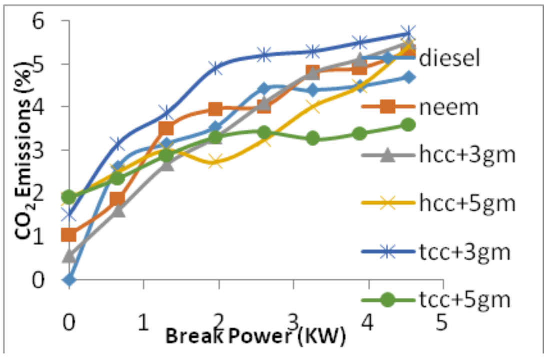


Fig: 4.6. CO_2 Emissions Vs Brake Power

From Fig: 4.6 it is observed that CO_2 emission increases with increases in brake power. The lower percentage of biodiesel blends emits very low amount of CO_2 in comparison with diesel. More amount of CO_2 in exhaust emission is an indication of the complete combustion of fuel. This supports the higher value of exhaust gas temperature. With this neem+3gm+hcc should be used for complete combustion process.

4.7.Un burnt HC Emission Vs Brake Power

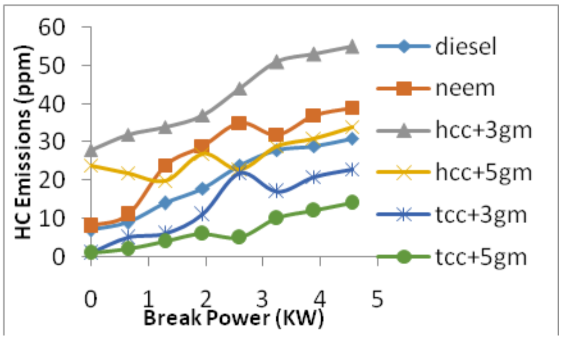


Fig: 4.7 HC Emissions Vs Brake Power

From Fig: 4.7 It is observed that an un burnt hydro carbon is more for fuel by using hemispherical combustion chamber. Whereas less for neem+5gm+tcc this is due to the reason that in toroidal combustion chamber the fuel will burn completely.

5. Conclusion

The experiments are conducted LHR engine concept to investigate the performance and emission characteristics of CI Diesel engine, using Neem biodiesel as a fuel and certain proportions of calcium carbonate nano fluid additives. The following conclusions are drawn.

- The specific fuel consumption is decreased about 4.08% using tcc with 3gm $CaCO_3$ compared to hcc with neem biodiesel(B100). This is due to piston geometry where proper air fuel mixing takes place.
- The test results reveals that BTE of the tcc with 3gm $CaCO_3$ neem biodiesel was increased about 3.9 % compared with hcc with 3gm $CaCO_3$ neem biodiesel. The improved air motion in TCC results proper air-fuel mixing.
- The mechanical efficiency of about 18.57% is more for hcc with 3gm $CaCO_3$ compared to diesel. Due to change in viscosity, the inertia forces are reduced, in turn net power developed is more.
- The NOx emissions are decreased when compared to diesel for tcc with 5gm $CaCO_3$ at full load operation, because with tcc combustion chamber geometry, it is possible to achieve favorable conditions such as squish, swirl and turbulence for combustion.
- The HC emissions are reduced using tcc with 5gm $CaCO_3$ compared to diesel. The oxygenated nature of biodiesel is found to enhance the complete combustion of the fuel, resulting in the reduction of HC emissions.

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