Experimental Study to Improve the Performance and Emission Characteristics of HCCI Engine using Blends of Bio-diesel and CNG

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Abstract - In search of a suitable fuel alternative to fast depleting fossil fuel and oil reserves and in serious consideration of the environmental issues associated with the extensive use of fuels based on petrochemicals, research work is in progress worldwide. In this thesis could find the gap that, many research paper works on different bio-fuels with diesel fuel. However, the cost of biodiesel is the major hurdle to its commercialization in comparison to petroleum-based diesel fuel. The high cost is primarily due to the raw material, mostly neat vegetable oil. Used cooking oil is one of the economical sources for biodiesel production. However, the products formed during frying, can affect the transesterification reaction and the biodiesel properties. So, In this thesis tried to derive objective by executing work for use of bio-fuels is waste cooking oil from palm oil blending with diesel fuel.The bio-diesel has been produced via trans-esterification process. The main purpose of trans-esterification process of oil is to separate glycerine from oil to reduce the boiling point, flash point, pour point, and especially the viscosity of oil. It is important to note that combustion process has almost the same or even better ignition and combustion properties in comparison to the reference diesel fuel. Reduce CO and NOx Emission compare to diesel fuel HCCI combustion is the potential to work with high thermal efficiency, low fuel consumption, and extremely low NOx and PM emission. Finally The Experiment is conduct to blend of palm-oil with diesel and CNG mode in HCCI engine.

***Key Words*: Homogeneous charge compression ignition engine, Diesel, Palm Oil, Bio-diesel, CNG, Performance and Exhaust emission**

1. INTRODUCTION

The internal combustion engine is the key to the modern society. There are two types of the IC engine namely the Spark Ignition (SI) engine and the Compression Ignition (CI) engine. Petrol and Diesel are at present the principle fuels for SI and CI engines. The IC engine is known to be one of the major sources of air pollution in the environment. And mainly responsible to global warming issues. The IC engine is known as one of the major sources of air pollutants in the environment. Bio diesel is capable of solving the problem of fuel supply in a decentralized fashion and simultaneously reduces environment related problems. HCCI engines are being actively developed because they have the potential to be highly efficient and to produce low emissions. HCCI engines can have efficiencies close to those of diesel engines, with low levels of emissions of NOx and PM.

2. Objective & Methodology

- Prepare The Palm Oil Bio-Diesel, Production, and Characterization.
- To modify of a single cylinder diesel engine run in to HCCI mode fueled with Diesel , Bio-diesel and CNG.
- HCCI Engine Performance Measurement.
- To Improve the Performance and Emission Characteristics.
- Reduce the Pollutant emission.
- Optimization of Diesel ,Bio-diesel and CNG

2.1 Transesterification process

Biodiesel will be prepared from raw Palm oil for the present study. The general transesterification process was followed for bio diesel preparation discussed below. Biodiesel is generally produced by transesterification of triglyceride;a triglyceride reacts with an alcohol in the presence of a strong acid orbase, producing a mixture of fatty acids alkyl esters and glycerol. The overall process is a sequence of three consecutive and reversible reactions, in which di and monoglycerides are formed as intermediates. The stoichiometric reaction requires 1 mol of a triglyceride and 3 mol of the alcohol. However, an excess of the alcohol issued to increase the yields of the alkyl esters and to allow its phase separation from the glycerol formed.

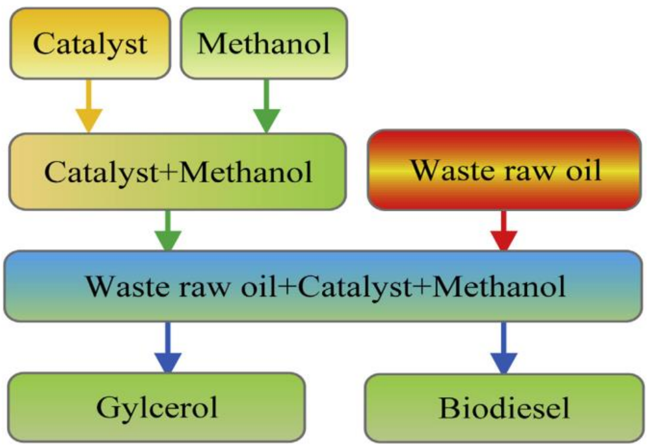


Figure 1 Transesterification Diagram

2.3 Properties of Bio-diesel And Diesel

Table 1 Properties of Bio-diesel And Diesel

Property	Method of Testing	Palm Biodiesel	Diesel
Kinematic viscosity at 40°C(cst)	U-tube	4.8	3.0
Density @15°C (Kg/m^3)	Gravimetry	876	833
Flash point(°C)	Open cup	130°C	74°C
Fire point(°C)	Open cup	171°C	120°C
Cloud point(°C)	ASTM D2500	13°C	-16°C
Pour point(°C)	ASTM D5853	17°C	-25°C
Calorific Value(KJ/kg)	Bomb calorimeter	38600	42850
Water content(mg/kg)	KF	411	105
Ceten no	ISO 5165	62.8	49.0
Acid value(KOH/g)	Tritrimetry	0.30	0.35
Total Glycerol Percent b Mass(% m/m)	GC	0.14	-----
Methanol Percent by Mass(% m/m)	GC	0.16	-----

3. Engine Modification.

- **Injector cut off set up**

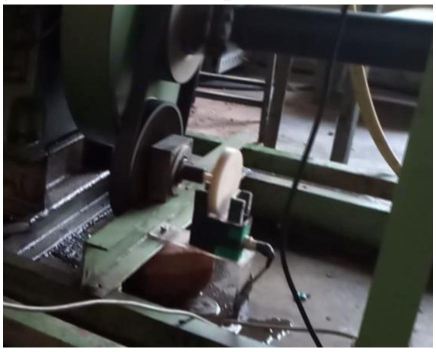


Figure 2 Mechanism for Injector cutoff

The optical sensor is used for the purpose of injector cutoff. The setup includes a pulley with a single window on it and a sensor system bundled in an acrylic C-shaped clamp. The C- shaped clamp has an optic ray emission end and the other end acting as the receiving end. The pulley is installed on a shaft extended from the crank shaft and it rotates with the speed of engine.

- **Vaporizer Installation**

The vaporizer is used for the purpose of vaporizing the fuel from main injector. This helps in the achievement of homogenous mixture in the engine cylinder. The installation of the vaporizer is on the extension pipe of the inlet manifold of the engine. At the end of the vaporizer, injector is attached at some angle that provides complete area of the heated pipe to be exposed to the injected fuel.

Figure 3 Vaporizer

- **Speed Measurement Mechanism**

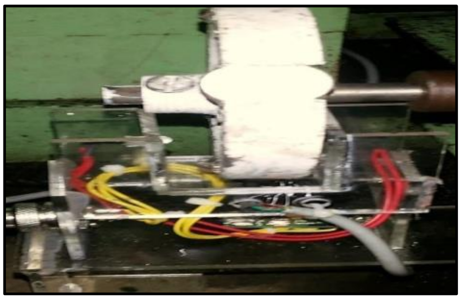


Figure 4 Speed Measurement with the help of pulley

The speed measurement is done with the help of the same pulley used in the injector cutoff mechanism. The pulley is installed with magnets on its periphery to create some magnetic field and the field is sensed by the proximate sensor attached to the C- shaped acrylic clamp. Hence the speed is displayed with the sensed data from this mechanism.

- **Data Acquisition System**

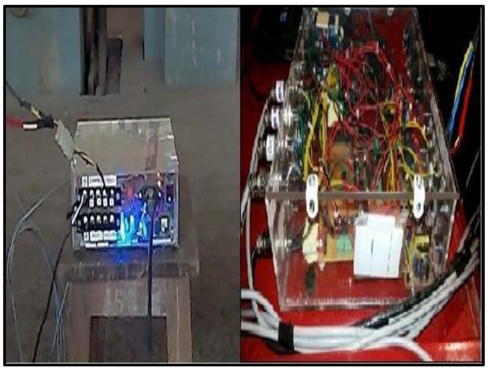


Figure 5 Data Acquisition Unit

The Data Acquisition Unit (DAU) has connectors for inputs from various sensors and also 4 LED lights.

- **Engine Setup Photos.**

Figure 6 Engine Setup

4 CNG composition and Properties

4.1 Natural gas composition

Table-2: CNG Composition

Composition	Formula	Volume Fraction (%)
Methane	CH4	91.82 - 94.39
Ethane	C2H6	2.91 - 4.66
Propane	C3H8	0.57 - 1.13
Iso-Butane	i-C4H10	0.11 – 0.21
N-Butane	n-C4H10	0.15 – 0.29
Iso-Pentane	i-C5H12	0.02 – 0.1
N-pentane	n-C5H12	0.02 – 0.08
Nitrogen	N2	0.96 – 4.46
Carbon Dioxide	CO2	0.26 – 0.81
Hexane	C6+C6H14	0.01 – 0.17
Oxygen	O2	0.01
Carbon Monoxide	Co	< 0.01

4.2 Properties of CNG

Table-3: Properties of CNG

CNG Properties	Value
Vapour Density	0.68
Auto Ignition	700°C
Octane rating	130
Boiling Point (Atm. Pressure)	-162°C
Air-Fuel Ratio (Weight)	17.24
Chemical Reaction with Rubber	No
Storage Pressure	20.6Mpa
Fuel Air Mixture Quality	Good
Pollution CO-HC-NOx	Very Low
Flame Speed m per sec	0.63
Combust. Ability with Air	4-14%

5. Engine set up

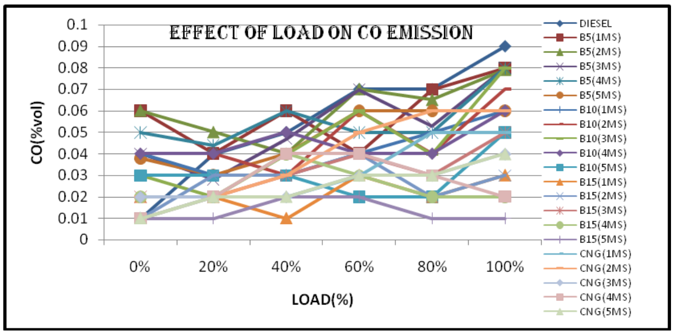
The experimental work has been carried out on a single cylinder, vertical, water cooled. four stroke and high speed diesel engine. The detailed specifications are given in table 4 and experimental setup is shown in figure 7. The engine is coupled with an eddy current dynamometer. The thermocouples are fixed to measure water inlet-outlet temperatures to engine and calorimeter, exhaust gas inlet-outlet temperatures to calorimeter and room temperature. These temperatures are shown on digital temperature indicator. The exhaust gas analyzer is connected to the exhaust pipe to measure the concentrations of gaseous emissions such as carbon monoxide, HC, NOx.

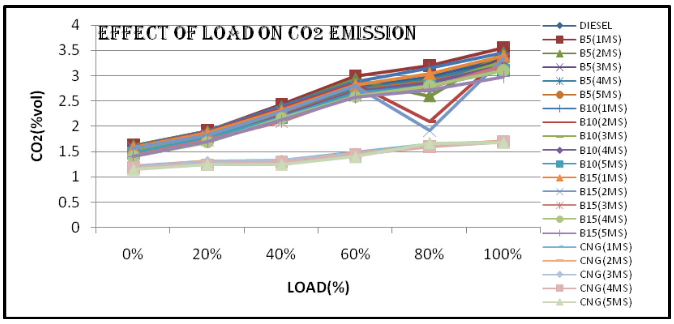
Table 4: Detailed specifications of engine set up

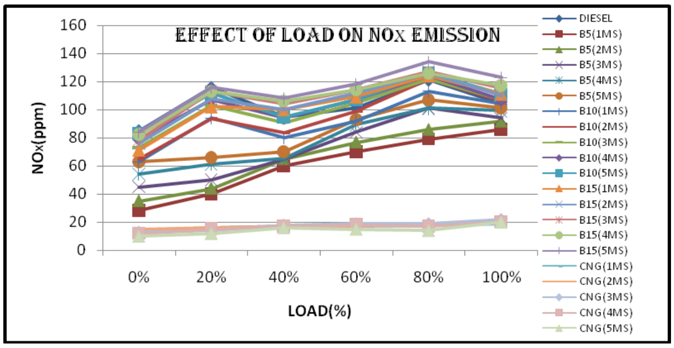
Engine	Kirloskar AVI
General details	Four stroke, CI, vertical, water cooled, single cylinder
Bore x stroke	87.5 mm x 110 mm
Compression ratio	17.5:1
Capacity	661 cc
Rated output	5.2 kW at 1500 rpm
Dynamo meter	Eddy current, water cooled.
Gas analyzer	BrainBee Automotive, model AGS-688

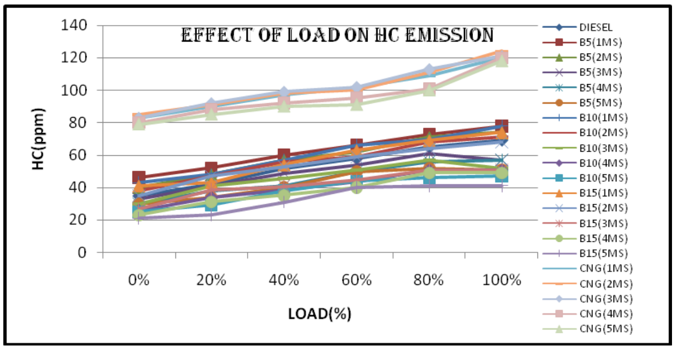
Figure 7 Test Engine

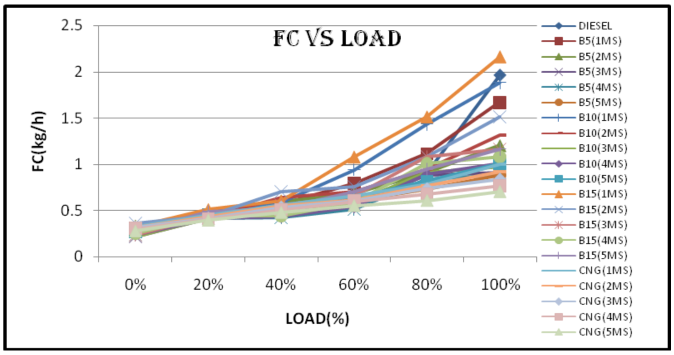
6. Result and Discussion

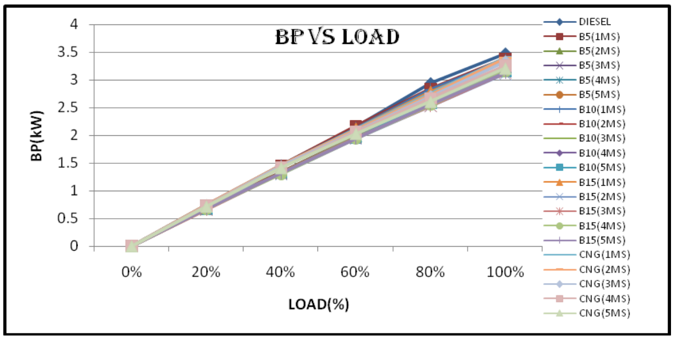


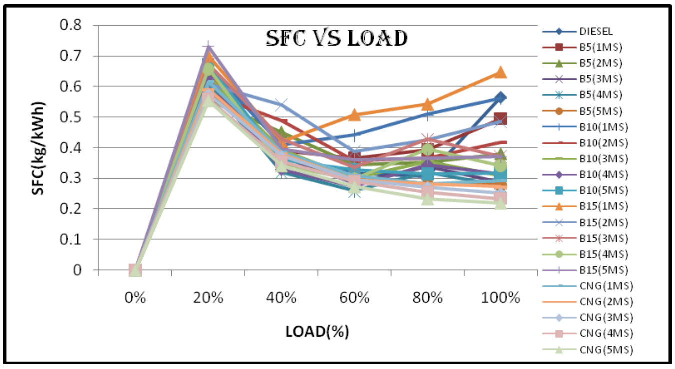


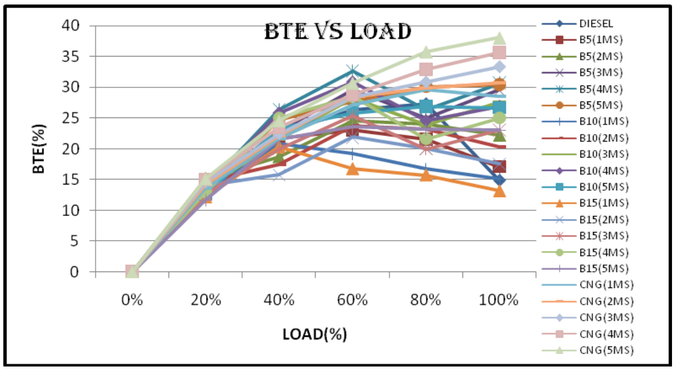












7. CONCLUSION

- The effect of Diesel,B5,B10,B15 and CNG with varying loads on Carbon monoxide emissions are concluded that the High load condition CO emission is lower for B5,B10,B15 and CNG compare to Diesel Fuel. For blending percentage increase than CO emission decrease.B15(5ms) is best result compare to all other fuels for emission of CO.
- The effect of Diesel,B5,B10,B15 and CNG with varying loads on Carbon dioxide emissions are concluded that the CNG fuel for all load and all ms condition CO_2 emission is lower compare to Diesel,B5,B10,B15 fuel. In bio-diesel for blending percentage increase than CO_2 emission decrease. In bio-diesel B15 for all load at 3,4,5 ms condition CO_2 emission is lower compare to Diesel,B5,B10 fuel. Then CNG is the best result compare to all other fuel.
- The effect of Diesel,B5,B10,B15 and CNG with varying loads on NOx emissions are concluded that the CNG fuel for all load and all ms condition NOx emission is lower compare to Diesel,B5,B10,B15 fuel. In bio-diesel blending B5 is Nox emission lower compare to other blending. In bio-diesel for blending percentage increase than NOx emission increase.
- The effect of Diesel,B5,B10,B15 and CNG with varying loads on NOx emissions are concluded that the HC fuel for all load and all ms condition HCemission is higher compare to Diesel,B5,B10,B15 fuel. In bio-diesel for blending percentage increase than HC emission decrease. B15(5ms) is best result compare to all fuels for emission of HC.
- The variations of Fuel consumption with varying Load under various Diesel,B5,B10,B15 and CNG are concluded that the fuel consumption of High load condition CNG is lower FC compare to Diesel,B5,B10,B15.A high load condition B15(1ms) is Higher FC compare to to Diesel,B5,B10,CNG. In bio-diesel for blending percentage increase than FC increase. B5,B10,B15 for all load at 3,4,5 ms condition FC is lower compare to Diesel fuel. B5 is most suitable compare to B10,B15.
- The variations of Break power with varying Load under various Diesel,B5,B10,B15 and CNG are concluded that the Break power of high load condition is lower of B5,B10,B15 and CNG Compare to Diesel. For B5,B10,B15 and CNG at 20% load and 1,2ms condition BP is higher compare to Diesel fuel.CNG is the best result compare to B5,B10,B15. In bio-diesel for blending percentage increase than BP decrease.
- The variations of Specific Fuel Consumption with varying Load under various Diesel,B5,B10,B15 and CNG are concluded that the Specific Fuel Consumption of high load condition is high SFC in B15(1ms) and lower SFC in CNG(5ms) compare to all other fuels. In bio-diesel for blending percentage increase than SFC increase.

- The variations of Break Thermal Eff. with varying Load under various Diesel, B5, B10, B15 and CNG are concluded that the Break Thermal Eff. of high load condition CNG is higher and B15(1ms) is lower compare to all other fuels. In bio-diesel for blending percentage increase than SFC decrease.

8. SCOPE OF FUTURE WORK

- By using blending of more than one alternative fuel can also be useful in HCCI engine for finding out the optimized results.
- One can also be used this blend with some additives for much improved performance characteristics.

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