RESEARCH ARTICLE OPEN ACCESS

Experimental Analysis of Performance and Emission Parameters of Neem Oil Ethyl Ester and HHO Gas Addition with Neem Oil Ethyl Ester in a Single Cylinder Four Stroke Compression Ignition Engine

J. Allen Jeffrey*, M Subramanian**
*Department of Automobile engineering, Hindustan University, Chennai-103
** Department of Automobile engineering, Hindustan University, Chennai-103

ABSTRACT
Need for alternate fuel is increasing day by day due various problems associated with the conventional fuels. Present work is focussed on analysing experimentally the performance and emission characteristics of Neem oil biodiesel and addition of HHO gas along with Neem oil biodiesel in a single cylinder compression ignition engine. Biodiesel is extracted by tranesterification of non edible crude Neem oil using ethanol and Naoh as catalyst. The biodiesel is blended with diesel. The blends used are N30 and N40. HHO gas is produced from the process of electrolysis the HHO gas is the combination of hydrogen and oxygen. The produced gas is made to pass through a moisture separator and sent along the intake manifold with the intake air. The performance and emission characteristics are noted down and compared. It was observed that there was a rise in brake thermal efficiency and lesser specific fuel consumption, Reduced Oxygen content in exhaust gases, lesser HC and CO emission and there was a rise in NO_X emission when HHO is supplemented with biodiesel
Keywords – Biodiesel, HHO (oxygen enriched hydrogen),Neem oil, Tranesterification

I. INTRODUCTION

The requirement of alternate fuel is gradually increasing day by day due to limited supply of fossil fuels a conventional engine requires diesel or petrol for its combustion. This combustion of fossil fuel releases huge amount of green house gases these gases catches the heat in the atmosphere and increasing price of fuel and scarcity alternate fuel that is biodiesel from vegetable oil is a good replacement for conventional petrol and diesel since there is not much modification required in a present IC engine. Vegetable oils have mesmerized attention and have a potential renewable source for the production of an alternative for conventional fuel. There are various outcomes from vegetable oils which have been utilized as an alternative fuel for compression ignition engines, including straight vegetable oil, mixtures of vegetable oil with diesel fuel known as biodiesel blends and alcohol esters of vegetable oils. Premkarthikkumar [1] has made an analysis of combustion emission and performance parameters of HHO Addition on a CI engine and observed that the brake thermal efficiency increased in terms of performance and in terms of emission observed that the CO emission decreased and NO_X and CO_2 emission increased on addition of HHO gases.ALIchanyilmaz [2] investigated experimentally the performance and emission parameters of HHO addition and observed that there was a reduction in HC and CO emission and reduced fuel consumption S.Bari[3]investigated experimentally the performance characteristics of H_2/O_2 gas addition and observed higher peak pressure the brake thermal efficiency increased and brake specific fuel consumption reduced. Nagarajan [4] investigated experimentally on performance and emission characteristics of Neem oil Methyl Ester and found out that improved brake thermal efficiency in certain blends and NO_X emission increased than diesel CO and HC emissions were quite low. This work deals with studying the performance and emission characteristics of biodiesel (Neem oil Ethyl Ester) blends N30 (30% biodiesel and 70% diesel) N40(40%biodiesel and 60%diesel) and HHO biodiesel blends in a single cylinder compression ignition engine HHO gas is produced from the process of electrolysis the produced gas is sent along the intake air. The extracted results are compared and studied.

II. MATERIALS AND METHOD

2.1Transesterification of Neem oil

Vegetable oils are triglycerides of fatty acids and alcohol esters of fatty acids have been prepared by the transesterification of the glycerides, wherein linear, monohydroxy alcohols reacts with the vegetable oils in the presence of catalyst to produce alcohol esters of vegetable oil. The alcohol esters of vegetable oil when used as an alternative diesel fuel have been identified as a biodiesel [15] .This process is the well known process for preparing biodiesel from raw Neem oil it is the process of breaking heavier molecules present in Neem oil into lighter ones. In this process 500 ml of crude Neem oil is taken in a flask and it is heated and maintained at a temperature of 50^0C-65^0C for 2hr and 45 min. Then 5grams of sodium hydroxide is completely made to dissolve with 100 ml of ethanol after dissolving sodium ethoxide solution is obtained. The obtained solution is poured in the 500 ml of neem oil which is maintained at 50^0C-65^0C. After pouring ethoxide solution the oil is stirred for another hour and the heated solution oil is poured in a separating flask for separating glycerol and Neem oil ethyl ester biodiesel and Neem oil ethyl ester (NOEE) is washed with 10% of distilled water to eradicate impurities the obtained NOEE is given for fatty acid test and it is blended with diesel.

Table (1) Fuel Properties of Neem oil biodiesel blends

Properties	Diesel	N30	N40
Viscosity (cst)	3.03	3.93	4076
Density (Kg/m^3)	816	831.1	839.9
Flash point (^{0}C)	52	67	71
Fire point (^{0}C)	60	73	76
Calorific value (KJ/Kg)	43796	40786	39467

2.2.GC/MS test

This test was conducted using a GC/ MS(Gas chromatography and mass spectrometry) data system which is used to find the fatty acids present in Neem oil biodiesel .The major fatty acids found generally in crude Neem oil is palmitic acid steatic acid and linoleic acid .A 2ml of NOEE is given for this test. GC/ MS analysis was conducted and it indentified four major acids present in Neem oil Ethyl Ester shown in table(1).

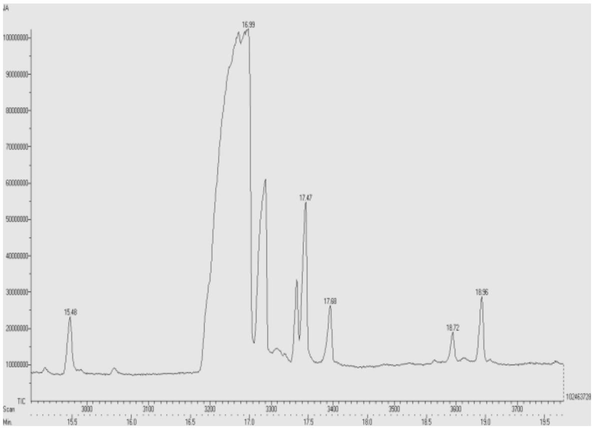

Figure (1) GC/MS Mass spectrum for Neem oil Ethyl ester

Table (2) Fatty Acid Ethyl ester in Neem oil Ethyl ester

SNO	Retention Time	Name of Ester	Fatty Acid	No of Ions	Scans
1	15.48	Hexadecanoic Ethyl Ester	Palmitic Acid	2144	2973
2	16.99	9-Octadecenoic acid Ethyl ester	Oleic acid	784	3263
3	17.68	Heptadecanoic Acid Ethyl ester	Margaric acid	2029	3396
4	18.72	11-Eicosenoic acid Ethyl ester	Gondoic acid	2108	3595

III. Experimental Setup

A single cylinder 4-stroke air-cooled vertical diesel engine with 3500 rpm was used. The schematic layout of the experimental set up is shown in Figure (1).A electrical dynamo was used for loading the engine. An Crypton five gas analyzer was used for the measurement of HC/CO, NO_X emission and the percentage of Oxygen in the exhaust gases. A burette is used to find the specific fuel consumption the HHO production unit draws power from a12 v battery the unit is fitted with a moisture filter and a flame arrester. The produced gas is sent after the air filter along with intake air the tests was conducted at a constant speed of 2000 rpm with variable load for diesel, Neem oil bio diesel and oxy hydrogen HHO addition with bio diesel.

Table (2) Specification of the engine

ENGINE	Greaves
MODEL	5520
NO OF CYLINDERS	1
TYPE	Four stroke air cooled
BORE	78mm
STROKE	83mm
CUBIC CAPACITY	325 cc
COMPRESSION RATIO	18:1

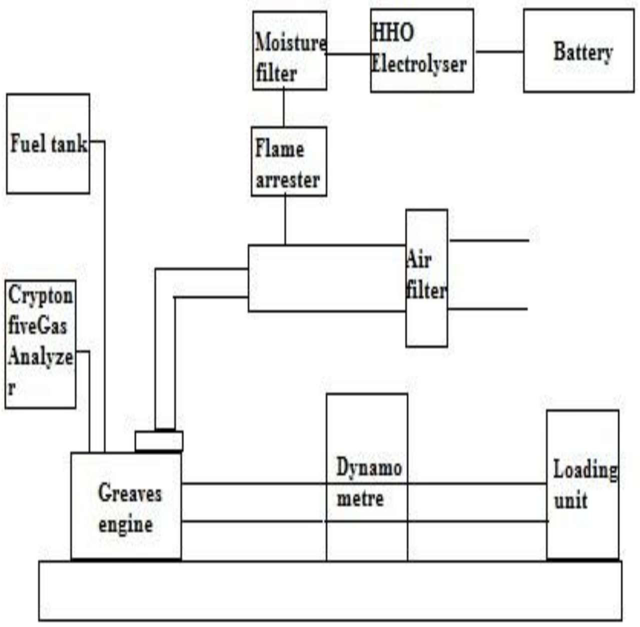

Figure (2) Experimental setup

IV. Results and Discussion

4.1 Performance characteristics

Brake thermal efficiency

Brake thermal efficiency is an important factor to measure the engine efficiency. It is defined as the ratio between the useful work available at the crankshaft of the engine to the input Energy given to the engine in the form of chemical energy available in the fuel the variation of brake thermal efficiency is shown in figure (3). The brake thermal efficiency

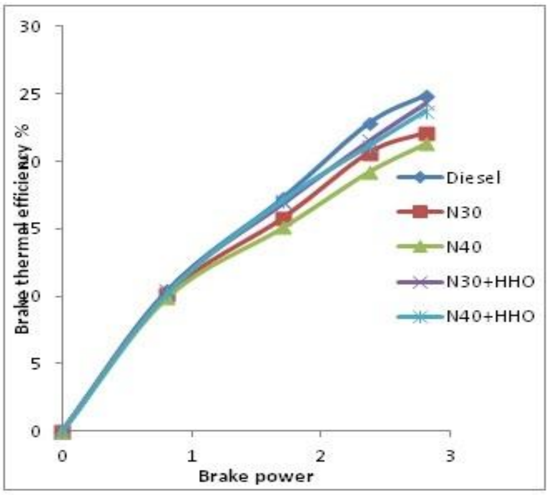

Figure (3) Variation of brake thermal efficiency

was observed to be less is in low loading condition of the engine.The maximum brake thermal efficiency was around 25% at full load that is when diesel is used as fuel it was the highest efficiency value compared to biodiesel and HHO biodiesel. When biodiesel blend N30 and N40 was used the efficiency dipped down to 22% and 21%. When HHO Gas is supplemented to biodiesel the efficiency raised to around 24%. Which is slightly higher than biodiesel the increase in brake thermal efficiency is due to oxygen content in HHO gas which pushes the fuel for better combustion and the addition of hydrogen has made the fuel burn rapidly. Hydrogen can act as a catalyst to improve the combustion.

Specic fuel consumption

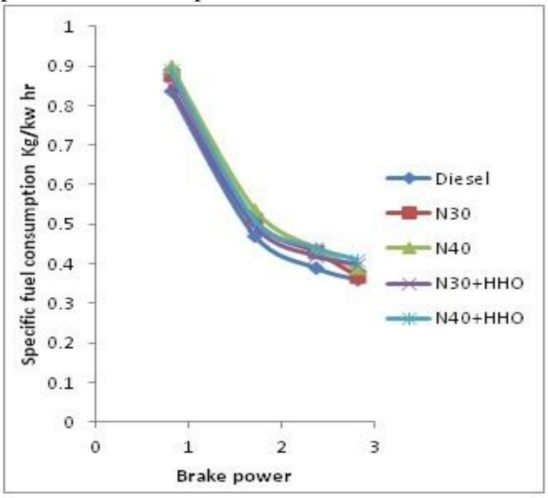

Figure (4) Variation of specific fuel consumption

The specific fuel consumption of an engine can be denoted in terms of specific fuel consumption in kilogram per kilowatt hour. It is an significant parameter that shows how capable is the engine performance it is inversely proportional to the thermal efficiency. The variation of the specific fuel consumption is shown in figure (4). The diesel curve remains at the bottom with least values the specific consumption for biodiesel increased but when HHO gas is supplemented it reduced but not less as compared to diesel.

4.2.Emission Characteristics

CO emission

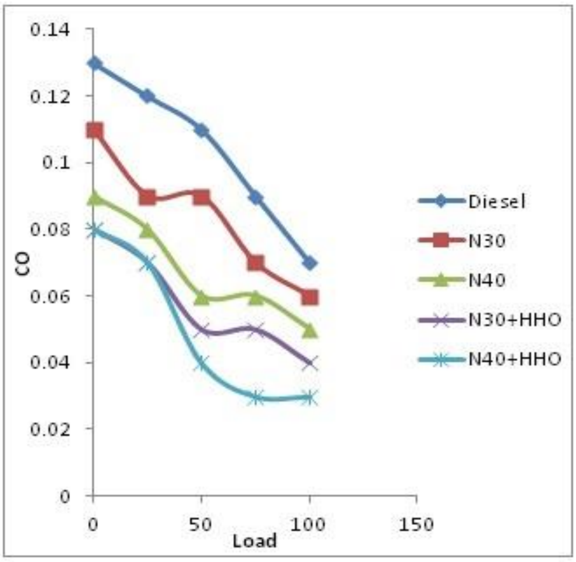

Figure (5) Variation of CO emission

CO emission is formed when there is not enough of oxygen to convert all carbon to CO_2. The variation of CO emission is shown in figure (5). The CO emission was more in diesel compared to biodiesel and HHO biodiesel the CO emission for diesel was around (0.07).The CO emission gradually decreased for biodiesel because of the oxygen content in NOEE (N30 and N40) the traces of oxygen can stimulate the combustion the CO emission was around (0.05) which is comparatively lower than diesel. The CO emission further decreased when HHO gas is supplemented with the biodiesel This is because of oxygen content in both HHO gas and biodiesel and another reason is absence of carbon in HHO gas.

HC emission

The variation of HC emission is shown in figure (6).The HC emission is because of rich fuel mixture and incomplete combustion. The HC emission was observed to be comparatively more in diesel than biodiesel and HHO biodiesel. When HHO gas is inducted with biodiesel the emission were lower than biodiesel blends (N30 and N40).

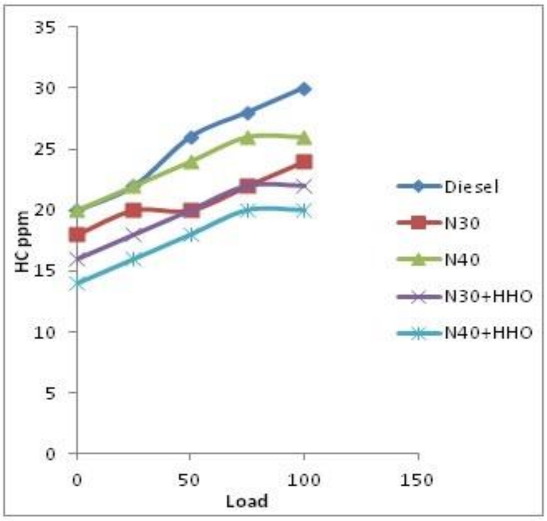

Figure (6) Variation of HC emission

With biodiesel as fuel the emission was around 26ppm at full load and with HHO biodiesel it was around 22ppm at full load. This reduction is because of increase in combustion rate.

NOX Emission

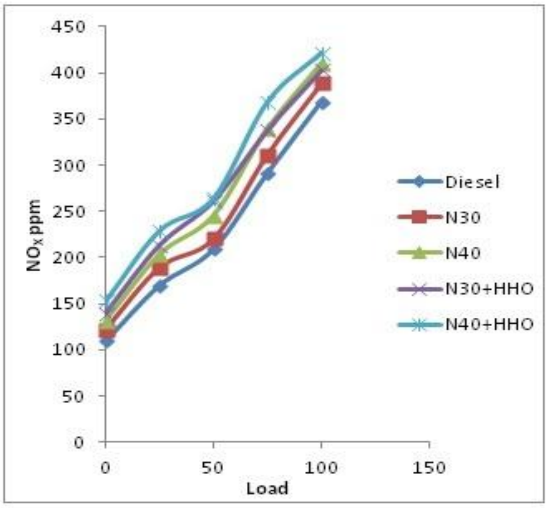

Figure (7) Variation in NO_X emission

This emission is caused mainly because of nitrogen parameter in air and the operating temperature of the engine. The variation of NO_X emission is shown in figure (7). The NO_X emission in diesel engine was around 368 ppm at full load which is the lowest emission when compared to biodiesel blends and HHO biodiesel. At full load the NO_X emission for biodiesel blends was around 388-410ppm and the NO_X emission for HHO gas addition along with biodiesel was around 403- 410ppm at full load which is highest amount of emission when compared to diesel and biodiesel blends this is because increase in operating temperature when HHO gas is added.

Oxygen content in the exhaust

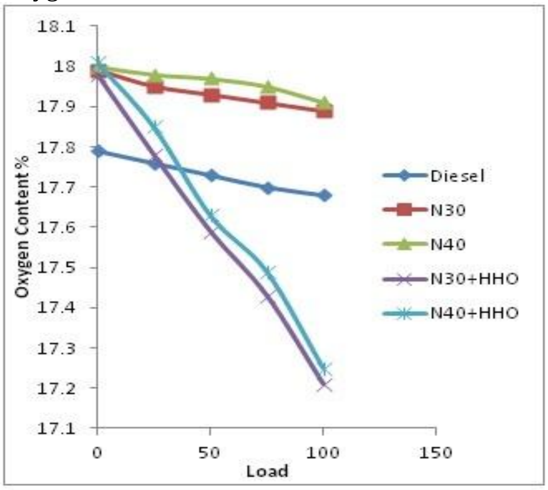

Figure (8) Variation of oxygen present in exhaust

The variation of Oxygen content in the exhaust gases is shown in Figure (8). The average percentage of oxygen content in exhaust gases when diesel is used as a fuel was around 17%. When the engine was operated at no load the percentage of oxygen content was 17.79% and when engine is operated at full load it was around 17.68% there was a minute amount of reduction in oxygen when diesel is used as fuel Now in case of biodiesel blends the oxygen content was around 17.99% and 18% at no load and 17.89% and 17.91%at full load it was observed that there was a minute reduction in oxygen content. But in case of HHO gas addition along with biodiesel blends the percentage of oxygen was around 17.98% and 18.01% at no load condition and it reduced gradually to 17.21% and 17.25% at full load this shows that hydrogen can enhance the combustion rapidly and reduce the oxygen content in the exhaust.

V. CONCLUSION

The single cylinder four stroke compression ignition engine was triumphantly functioned with NOEE blends and HHO NOEE blends and the following results are concluded based on experimental investigation

- The brake thermal efficiency increased when HHO gas is supplemented with Biodiesel compared to biodiesel blends.
- The specific fuel consumption remained low for HHO supplementing biodiesel compared to biodiesel blends.
- The CO emission were low for both biodiesel and HHO biodiesel compared to diesel but in terms of biodiesel and HHO biodiesel the emission were low for HHO biodiesel.
- The HC emission were low for biodiesel and HHO biodiesel compared to diesel but HC emission was high for biodiesel compared to HHO biodiesel.
- The NO_X emission was observed to be high in HHO biodiesel than biodiesel. There was an rise in NO_X emission in both biodiesel and HHO biodiesel when compared to diesel.
- The oxygen content in the exhaust gradually reduced when HHO is supplemented with biodiesel when compared to diesel and biodiesel blends this shows that HHO gas can enhance the combustion.

ACKNOWLEDGEMENTS

The Authors likes to thank the Department of Automobile Engineering Hindustan University for their kind co-operation and SAIF lab IITM.

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