Performance and Emission Characteristics of Pongamia Biodiesel with HHO Gas in Compression Ignition Engines

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ABSTRACT

Nowadays the environmental pollution has been increased incredibly by using conventional fuels. To control this increase in pollution alternate fuels has to be used as supplement for conventional fuels. While using conventional fuels such as petrol and diesel in IC engine there is a chance of increase in emissions. Alternate fuels can control emissions. This work is based on the investigation of emission parameters of pongamia biodiesel and HHO gas addition in a CI engine. Pongamia biodiesel is extracted by the process which is known as transesterification. Transesterification is the process which is used to convert raw vegetable oil into biodiesel with the use of catalysts such as NaOH, KOH, ethanol, methanol, etc. HHO is a gas which is produced by the process of electrolysis. Electrolysis is the process of converting liquid state to gaseous state in the presence of electrically charged ions. By introducing oxy hydrogen with air and using a biodiesel oil to ignite the mixture by using dual fuel mode. When the biodiesel quantity is too small to produce effective ignition, that is failure of ignition and when the hydrogen air mixture is so rich that the combustion becomes unbelievably high. This combination of fuels can reduce HC and CO emission and increase in NOx. And this investigation proves that beyond a certain range (30 to 40%) substitution of biodiesel fuel by hydrogen.

KEYWORDS: Biodiesel, HHO (oxy-hydrogen), Pongamia oil, Transesterification, Electrolysis, dual fuel mode.

I. INTRODUCTION

The price of the conventional fuel is increasing day by day so, an alternative fuel is needed in these days and fuel economy of engines is getting improved and will continue to improve. The internal combustion engines need fuels like petrol and diesel to perform. So an alternative fuel requires the properties of petrol or diesel for the combustion, and at the same time it should concern over the exhaust emission problems that is occurred by the conventional fossil fuels. Alternative fuel used here is biodiesel and oxygen enriched hydrogen. Biodiesel is produced by transesterification of raw vegetable oils. In this transesterification process the raw non edible crude oil is converted into biodiesel by using NaOH and ethanol as a catalyst. It can be produced from both natural and manufactured. Biodiesel from vegetable oil is the best supplement for conventional fuels since both have similar fuel properties for combustion. Bio diesel is considered as a type of renewable resource and bio diesel is much cleaner and has less pollution than conventional fuels. Bio diesel helps the fuel slippery and the engine running. HHO (oxy-hydrogen) is supplemented in the intake manifold along with the intake air of the compression ignition engine. HHO is also known as renewable energy. Since it is in gaseous state it is dangerous to store, so it should be supplied directly into the intake manifold. Its main objectives are if fuel leakage occurs to environment is not a pollutant and it obtained by using different ways like electrolysis of water. By introducing oxyhydrogen with air and injection of pongamia biodiesel to ignition takes place inside the engine cylinder by using dual fuel mode. This investigation deals with engine performance with low fuel consumption and emission parameters of pongamia oil ethyl ester with HHO gas addition in C. I engine. Then determined results are compared and studied.

II. MATERIALS AND METHODS

a. Biodiesel

Biodiesel is can be developed by different ways such as transesterification process. Biodiesel is extracted by various kinds of sources, both natural and manufactured like vegetable oil. Biodiesel is the most important precious renewable energy source. Which is can be used in compression ignition engine without any modification. It is a cleanable burning fuel. While using Biodiesel in a C. I engine there is no toxic emission presented in its exhaust emission and it is used to reduce HC and CO gradually with variable blends such as B10, B20.

b. Transesterification of Pongamia oil

In this transesterification is a process which is used to converting raw pongamia oil to biodiesel by using NaOH and ethanol as a catalyst. This non edible crude oil has a high content of triglycerides and alcohol esters of fatty acids have been prepared by this process of glycerides, then the monohydroxy alcohols reacted with the raw pongamia oil in the presence of catalyst like NaOH to obtain alcohol esters of pongamia oil. It is always identified as a pongamia biodiesel. This transesterification process is the well understood method to prepare biodiesel by using non edible crude oil. And it can be used to recycle polyesters into individual monomers. It also helps to convert the fatty acids into biodiesel. This process consists of some different kinds of materials like raw pongamia oil, NaOH pellets, ethanol. In this process 500 ml of non-edible crude pongamia oil is taken into the flask and it is placed on the furnace and heated up to 65℃. In this process the temperature should not be above 65℃. Then it is continuously heated and maintained at a temperature of 55-65℃ for 2hr and 45 mins. Before completing this step 5 grams of sodium hydroxide taken into another flask and allow it to dissolve completely with the atmosphere. Then 100 ml of ethanol taken into the beaker to mix the dissolved NaOH. After this step sodium ethoxide solution is obtained. Then it is poured to the 500 ml of pongamia oil and maintain the temperature between 55-65℃. Then the oil should be stirred for another one hour and the heated solution is poured in separating flask to separate glycerol and pongamia oil ethyl ester biodiesel and it is washed with the distilled water to remove impurities from the pongamia oil ethyl ester. Then finally obtained Pongamia oil ethyl ester is given for fatty acid test and then blend with the conventional fuel like diesel.

c. Fuel properties of pongamia biodiesel

Table (1) fuel properties of pongamia biodiesel

Property	**Unit**	**Value**
Calorific value	Kcal⁄kg	8746
Cetane number	-	42.5
Density	g⁄cm2	0.929
Flash point	℃	226.5
Fire point	℃	231.3
Viscosity	mm2⁄sec	40.9
Boiling point	℃	319

III. EXPERIMENTAL SETUP

In this experiment is mainly consist of following components such as single cylinder four stroke air cooled vertical compression ignition engine with 3500 rpm, electric dynamo, crypton five gas analyzer and hydrogen generator. The schematic layout of this experimental setup is shown in below figure (1). The electric dynamo was used to loading an engine with variable conditions. A Crypton five gas analyser was used to measure the percentage of HC, CO, NO_X and Oxygen contents in the exhaust gases from engine exhaust. A burrete is used to find the specific fuel consumption. And hydrogen generator is used to generate the oxy hydrogen (HHO) gas. The HHO production unit draws power from a 12 v battery and it is connected to hydrogen generator electrodes. Then the electrolysis process takes place inside the generator to oxyhydrogen can be obtained. And this unit is fitted with a moisture filter and a flame arrester. And this is used to avoid the moisture and flame enter into an engine inlet. 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 with addition of HHO gas and oxy hydrogen HHO addition with the pongamia bio diesel.

Fig (2) Experimental setup

IV. RESULT AND DISCUSSION

EMISSION PARAMETERS

While combustion process takes place inside the cylinder which is used to generate power by using conventional fuels. An engine exhaust consists of variable pollutants like Hydrocarbon(HC), Carbon monoxide(CO), Nitric oxide(NOx) and little bit of Oxygen contents. These variables can be measured by using crypton five gas analyser.

CO emission

Carbon monoxide is a colourless and odourless but a poisonous gas, which is the main cause of global warming and acid rain. This can be obtained in an engine when operated with the fuel rich equivalence ratio. When combustion process takes inside the cylinder there is not enough oxygen to convert all carbons into CO2, because some fossil fuels does not completely burn and some carbon ends up as CO. The emission of CO to the atmosphere depends on these factors like excess gas supplied for burning fossil fuel, local rich regions, incomplete combustion process takes place inside the cylinder, stabilisation of flame and size of combustion chamber. While using dual fuel mode such as biodiesel and addition of HHO gas supplemented to an engine there is occurs low emissions. Essentially less amount of CO in the exhaust as there is no carbon in hydrogen gas.

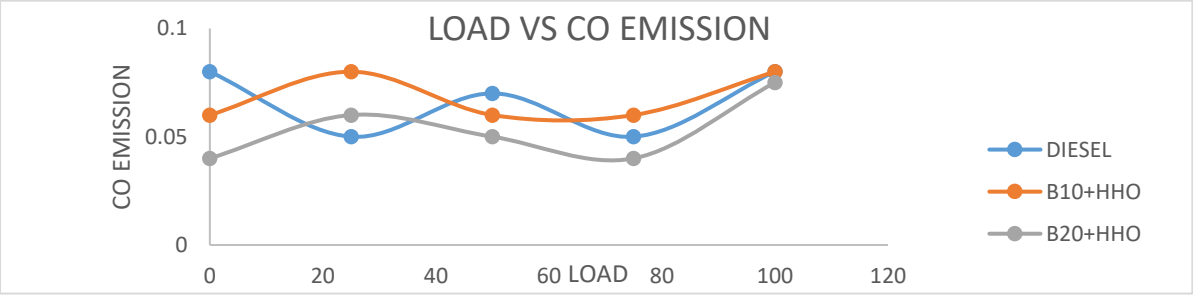

Fig (3)variation of CO emission

HC emission

Hydrocarbon emissions can be emitted by an engine because of unburned fossil fuels and irregular operating conditions. Generally, C.I engines can emit comparatively low levels of hydrocarbons. The HC emission is mainly depending on type of fuel used to combustion process takes place inside the cylinder and engine structure and it is can be occurring at variable loading condition. The variation of hydrocarbon emission is can be comparatively analysed below chart. This chart explained about variation of diesel and biodiesel with the addition of HHO gas supplemented to an engine. Then HC emission is comparatively lower than the diesel used as a fuel. Because while using Hydrogens gas is essentially no HC in the exhaust as there is no carbon contents presented in fuel. And the same way biodiesel has carbons to produce HC. Then the biodiesel with the addition of HHO gas is to produce less amount of hydrocarbons. Then this HC emission is can be found by using crypton five gas analyser. Which is used to displayed the percentage of hydrocarbons presented in an engine exhaust.

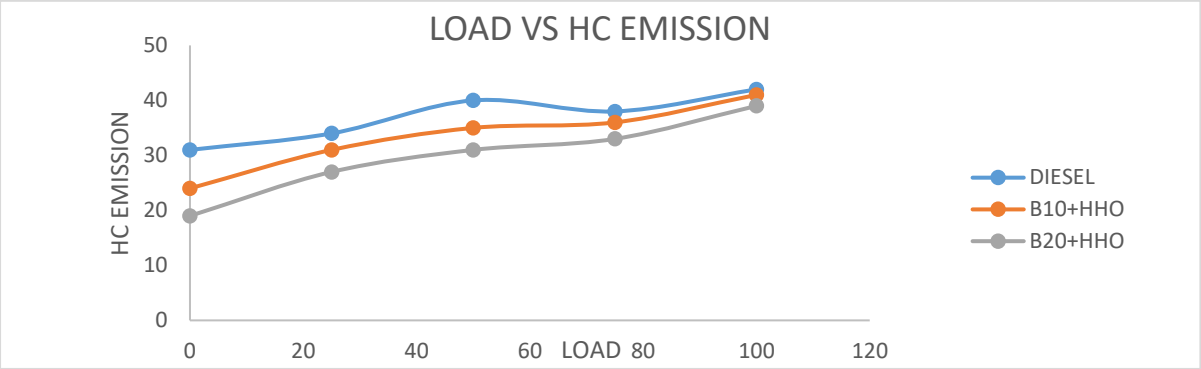

Fig (4) variation of HC emission

CO_2 Emission

CO_2 emission is the most polluting element which is leads to global warming and acid rain. And this emission can occur due to combustion of conventional fuels will affect atmospheric climate and develop global warming which could turn fertile land into deserts. It is an unavoidable polluting element of the combustion process. While using biodiesel with the addition of HHO gas supplemented to an engine there is less amount of carbons used to produce a carbon dioxide. Because CO2 presents in an exhaust there is complete combustion occurs in an engine. The above graph explains about variation of carbon dioxide emission due to variable loading conditions.

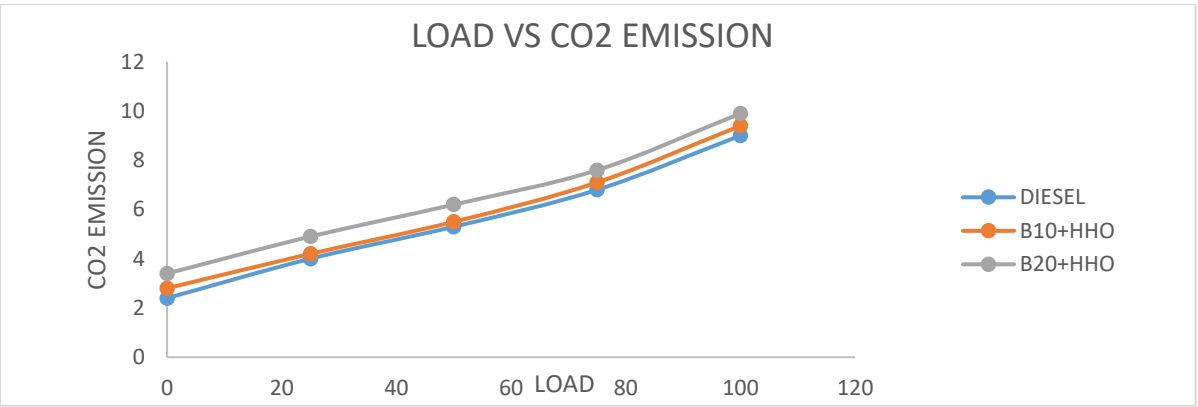

Fig (5) variation of CO2

NOx emission

NOx is can be obtained by the combustion of fossil fuels like petrol and diesel in air is accompanied by the formation of nitric oxide. NOx is produced at high temperature zone developed during combustion process takes place inside the combustion chamber. NOx is higher than petrol engines because C.I engines have higher compression ratios, pressure, temperature and it is depending upon the location of indirect injection system tends to generate high amount of NOx emission. the variation of NOx emission is can be clearly explained in below chart. This chart is used to conclude the NOx emission is comparatively higher than diesel.

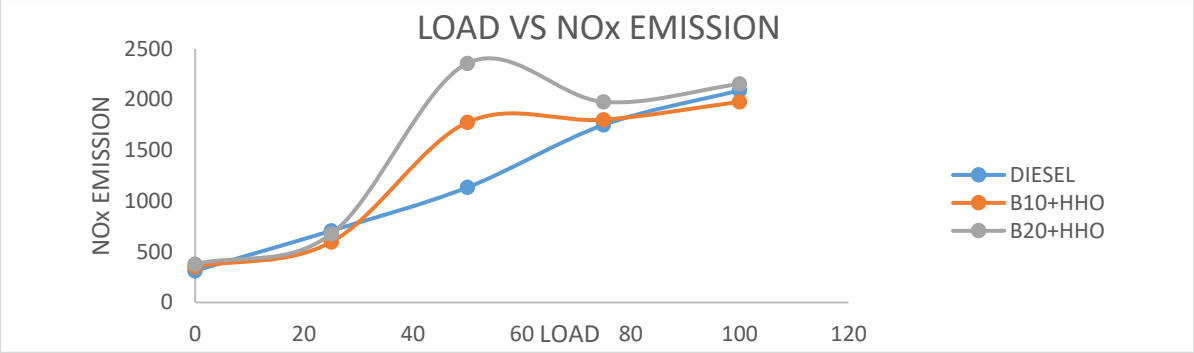

Fig (6) variation of NOx emission

O_2 emission

O_2 emission is nothing but it is a one of the element in an engine exhaust. Then it can be found by using a device such as crypton five gas analyser. Which is used to find out the percentage of variable elements presented in an engine emission. Then O2 is one of the non-polluting engine exhaust element. The above chart is explained about variation of oxygen content presented in an engine emission. Which is conclude that the o2 emission is comparatively higher than diesel used as a fuel in a C.I engines.

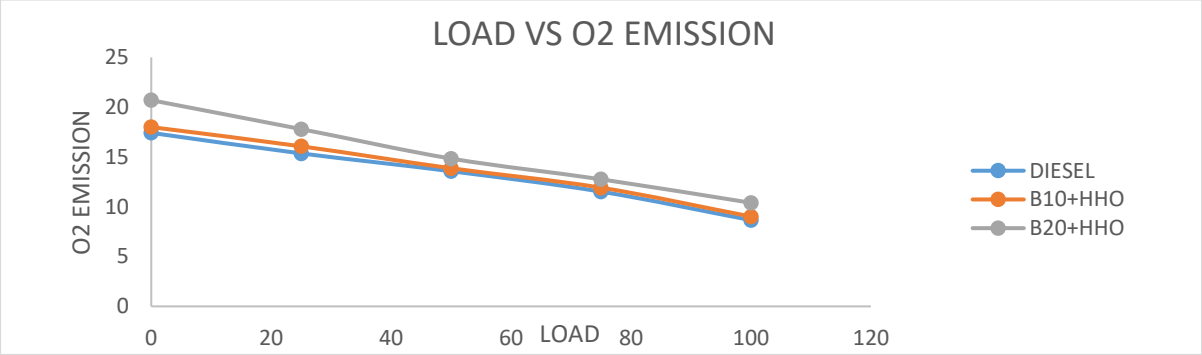

Fig (7) variation of O_2 emission

V. ENGINE PERFORMANCE

Mechanical efficiency

It is an another one of the important engine performance parameter. Which is used to find out the engine performance and capacity at different loading conditions. The mechanical efficiency is can be defined as the ration of break power (delivered power) to the indicated power (power provided to the piston). The below chart is used to explained about variation of mechanical efficiency obtained during combustion process takes place inside the combustion chamber in both diesel and biodiesel at variable loading conditions.

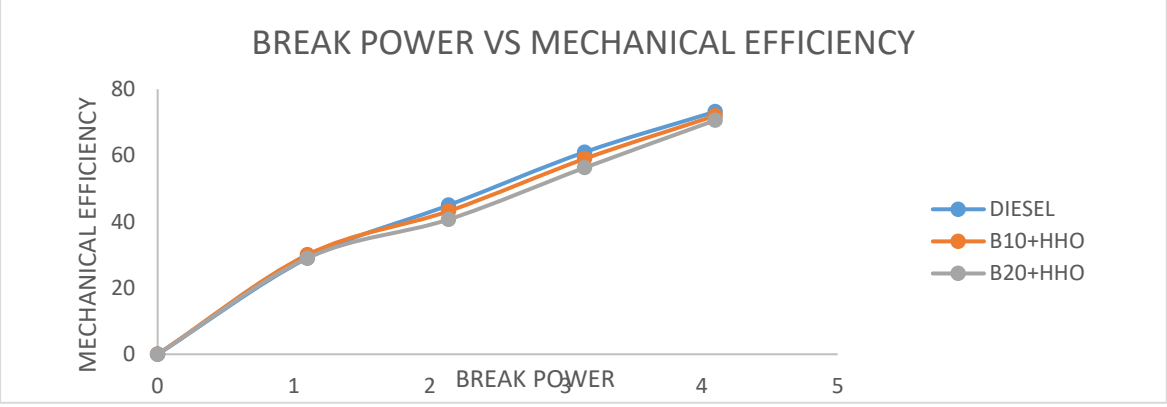

Fig (8) Variation of Break power vs Mechanical efficiency

Break thermal efficiency

It is also an important element which is used to find out the engine performance and capability of an engine with variable loading conditions. It is the one of the engine performance parameter. It is can be determined as the ratio of energy in the break power, to the input of fuel energy in appropriate unites at different loading conditions. Then the below chart is used to explained about variation of break thermal efficiency obtained during combustion process occurs inside the cylinder. And this is the important term which is used to find engine capability.

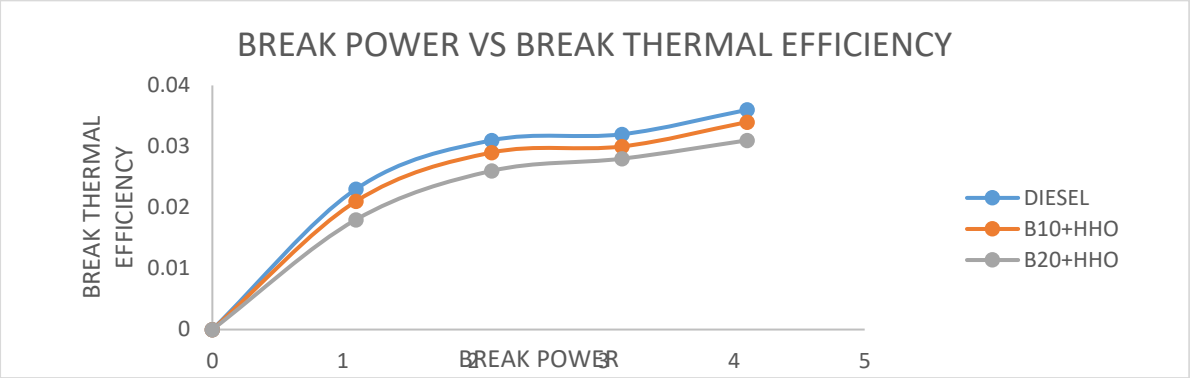

Fig (9) Variation of Break power vs Break Thermal efficiency

Specific fuel consumption

It is the most important parameter which is used to analysis the engine performance during combustion takes place inside the cylinder. Generally, fuels used in IC engine should have variable qualities which are important for the smooth running of the engine. They are knock characteristics, volatility, staring characteristics, smoking and odour, viscosity, corrosion and wear, handling ease. The above graph is explained about variation of specific fuel consumption while combustion process takes place inside the cylinder. When dual fuel mode action takes into a compression ignition engine there is comparatively low fuel consumption occurs in an engine performance. Because, the combination of pongamia biodiesel with addition of Oxy hydrogen (HHO) have high effective ignition and combustion becomes unacceptably violent.

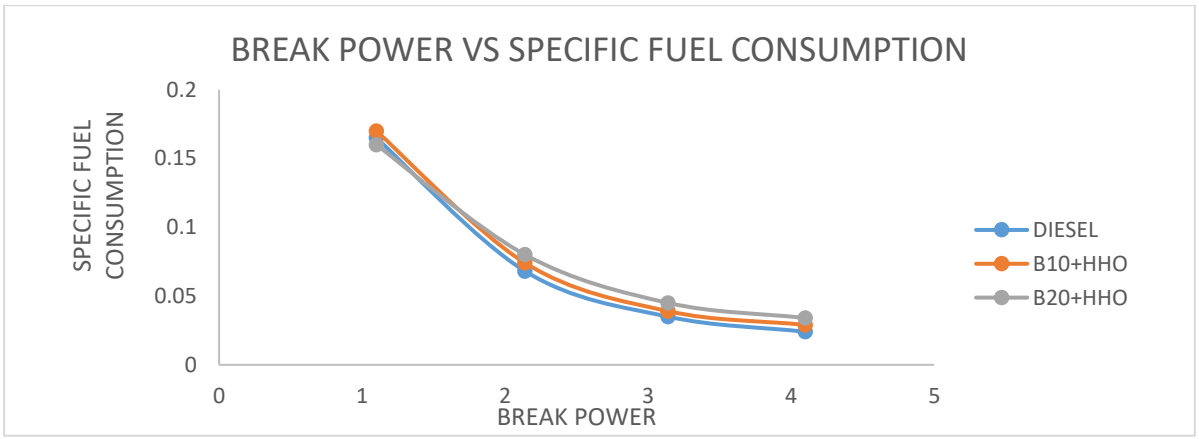

Fig (10) Variation of Break power vs. Specific fuel consumption

VI. CONCLUSION

The single cylinder four stroke compression ignition is successfully run by using blends of Pongamia biodiesel with addition of Oxyhydrogen (HHO) gas. And this function is also known as a condition of dual fuel mode. Then an engine performance and emission parameters can be concluded is based on this experimental investigation.

- CO2 emission were high by using Pongamia biodiesel with addition of HHO gas supplemented to an engine. And it is comparatively higher than using conventional fuel such as diesel.
- While using dual fuel mode combustion process in an engine the Co emission is comparatively lower than using conventional fuels. Because, the fuel consumption was low.

- NOx emission were high by using dual fuel mode, which is comparatively higher than other variable fuels.
- O2 emission is comparatively high by using blends of biodiesel and HHO addition in an engine to other conventional fuels, which is can be measured by crypton five gas analyzer.
- And this blends of Biodiesel and HHO addition in an engine which is improve engine performance like low fuel consumption, high mechanical efficiency, high thermal efficiency

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