Utilization Of Brown Gas As A Supplemental Fuel In The Diesel Engine As Pre-Combustion Exhaust Emission Reduction Method.

P. T. Sowba [1], N. Ravichandran[2] and Dr. R. Senthil [3]

[1] P.G. Student, Anna University, Villupuram Campus, Tamil Nadu, India
.

[2] Research Scholar, Anna University, Villupuram Campus, Tamil Nadu, India.

[3] Dean i/c, Anna University, Villupuram Campus, Tamil Nadu, India

Abstract:

Drastic increase in need of fossil fuels, inevitable decline of its availability, rapid increase of emissions like HC,CO, NOx, smoke, particulate matters and CO_2 leads to search for an Alternative to fulfill the future demands. Because of high compression ratio and lean operation, Diesel engines have excellent thermal efficiency. But at the same time it has encountered serious emission problems like NO_x, Particulate matter, Smoke, lesser amounts of HC and CO that results from its operation. Many in- cylinder and exhaust post-treatment and pre-treatment techniques are currently being investigated to reduce those emissions to acceptable levels in Diesel engines.

Brown Gas or Oxy Hydrogen (HHO) can be used as a supplemental fuel in Diesel engines for gaining better fuel economy, better engine performance and less exhaust emissions. HHO is produced by breaking the molecular bonds of water by the electrolysis method. In this Investigation, the performance and emission characteristics of were studied on single cylinder, direct injection, hand operating four-stroke stationary diesel engine coupled with eddy current dynamometer were studied. When HHO is added in the inlet manifold, it is sucked into the combustion chamber along with air. During combustion, it enhances quality of fuel burn and reduces the combustion temperature inside the combustion chamber which results in good engine performance and less Exhaust emissions.

1. Introduction

The enormous increase in the fossil energy has caused increased pollution of air, with its exhaust emissions being a significant contributing factor. In recent years, researches are being carried out to minimize the harmful emissions and to improve engine performance of the IC engines. In that way, Browns Gas or HHO or Oxy hydrogen, is commonly known to be a safe, effective, high performance fuel when added, in measured amounts, to an internal combustion engine.

1.1 Brown Gas as a Supplemental fuel

Brown Gas (HHO) is a mixture of 2/3 of hydrogen and 1/3 of oxygen (O_2) by volume. This gaseous mixture is used for torches for the processing of refractory materials and was the first gaseous mixture used for welding.

When water is introduced with electrical DC (Direct Current) it divides into its primary elements of Hydrogen and Oxygen. The Hydrogen and Oxygen rise from the liquid water as a gas. The gas is called HHO. This gaseous mixture is widely used as a clean burning high energy renewable fuel. The reaction is

On electrolysis: H_2O + DC current$\rightarrow$ HHO(g)

Once produced, the gas is introduced into the air intake of the engine. HHO is then pulled into the engine because of the vacuum created inside the cylinder. The HHO combines with the air, gets combusted and the gas mixture converts to water vapour and releases a massive amount of cool clean renewable energy. The water vapour thus formed instantaneously cools the combustion chamber and cancels out the initial higher temp, but not before increasing the efficiency of the fossil fuel burn.

On combustion: HHO+ Air $\rightarrow$ H_2O + Energy (241.8kJ)

1.2 Properties of Brown Gas:

For a stoichiometric mixture, Oxyhydrogen (HHO) gets combust when brought to its auto ignition temperature of about 570^0C at normal atmospheric pressure. When ignited, the gas converts to water vapour and releases energy of about 241.8 kJ of energy (LVH) for every mole of H2 burned. At normal temperature and pressure, it can burn when it is between 4% and 95%

hydrogen by volume. The amount of energy released is independent of the mode of combustion.

2. Experimental Setup

The engine used for the investigation is a four-stroke, water cooled, single cylinder, direct injection, vertical Diesel engine running at a rated power of 5.2kw at 1500 rpm. The technical specification is shown in table 1 and the schematic of the experimental set up is shown in fig.1.

Table 1. Specification of the engine.

Make of the engine	Kirloskar, model TVI,water cooled,vertical type
Type	Compression ignition
Fuel	H.S.Diesel
Number of strokes	4 in line
Number of cylinder	One
Rated power	5.2kw@1500 rpm
Bore/Stroke(mm)	87.5/110
Compression ratio	17.5:1
Swept volume(cc)	661

HHO fuel system consists of titanium electrodes, 200 ml of distilled water stirred with NaCl, Pulse width modulator, Battery (9volts), moisture filter and Back fire arrestor. Distilled water is poured into the electrolyzer till the electrodes gets submerged. The electrodes are connected to positive and negative terminals so that DC current is flow into it. When the current passes into salted distilled water, molecular bonds gets breaks up and HHO gas is formed. It is passed into inlet manifold through nozzle of the HHO fuel system. Since HHO is lighter than water, it flows into cylinder along with air easily. HHO is supplied to the inlet manifold from the on board HHO fuel system set up. The pulse width modulator is used to regulate the voltage supply into the electrolyser set up. The HHO thus produced is passed to fire arrestor for avoiding back fire in the inlet system. Before passing into the inlet manifold, It is allowed in to moisture filter to absorb the moisture in HHO gas to make it dry.

The engine is started with diesel fuel; then HHO was supplied to the intake manifold upto the rated speed 1500 rpm. The Emissions are measured by allowing the smokemeter and five gas analyser tail pipe into the exhaust manifold alternatively. By varying the load and speed of the engine at regular intervals, the following parameters are measured.

- Brake Power
- Brake Specific Fuel consumption
- Thermal Efficiency
- Volumetric Efficiency
- Engine exhaust temperature
- Emissions like CO,HC,CO2,NOx, and Smoke

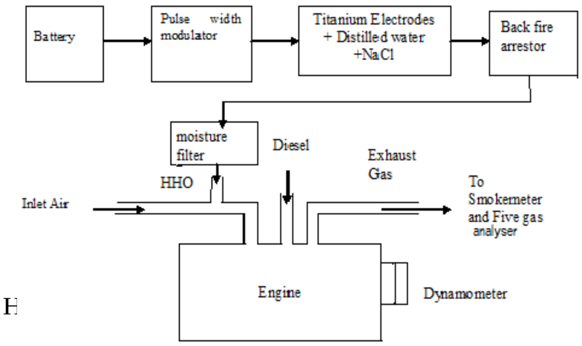

Fig.1 Experimental set up of HHO fuel system in the Diesel Engine

3. Results and Discussion

In this Experiment, the performance parameters like Brake Power, Fuel Flow, Brake Specific Fuel consumption, Thermal Efficiency, Volumetric Efficiency and emissions like Carbon monoxide, Hydrocarbons, Carbon dioxide, Oxides of Nitrogen, Engine exhaust temperature were measured and analyzed for with and without supplemented Oxy hydrogen along with air in diesel engine.

The Experiment was carried out at constant Oxy Hydrogen flow rate of 0.9l/min along with air.

3.1 Brake thermal efficiency

The variation of Brake thermal efficiency for different values of Brake Power for with and without supplemented oxy Hydrogen is shown in fig 2. The Brake thermal efficiency obtained for 0.9lit/min Oxy hydrogen with air at full load. It is analyzed that the brake thermal efficiency increases in Oxy hydrogen supplemented engine since HHO better mixes with air at leaner ratio in the normal diesel engine.

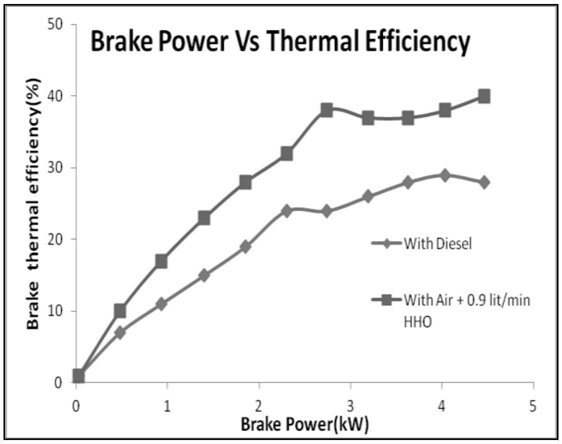

Fig.2 Variation of Brake Power with Thermal Efficiency

3.2 Brake specific fuel Consumption

Fig. 3 shows the variation of Specific fuel consumption with Brake Power for with and without Oxy hydrogen supplement in diesel engine along with air. It can be observed that SFC without Oxy hydrogen is 49.99 Kg/Kw hr, where with Oxy hydrogen; it is 34.29 Kg/kwhr. It is noted that there is 31% of reduction in fuel consumption due to the utilization of Oxy hydrogen as a supplemented fuel which enhances the combustion of air fuel mixture at leaner air fuel ratio.

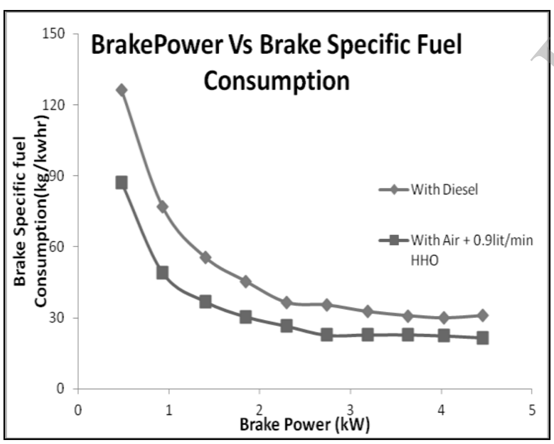

Fig. 3 Variation of Brake Power with BSFC

3.3 Oxides of nitrogen

The variation of Oxides of nitrogen with Brake Power for Oxy hydrogen supplemented fuel and only diesel fuel is depicted in Fig. 4.The NOx formation is high in diesel fuelled engine due to high temperature inside the combustion chamber which is 788 ppm at full load where as in oxy hydrogen supplemented fuelled engine, it is 583 ppm at full load. There is about 15% of reduction in NOx formation since it reduces the peak temperature inside the engine.

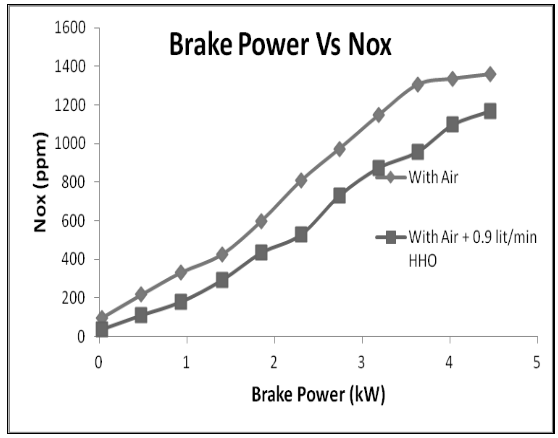

Fig. 4 Variation of NOx with Load

3.4 Smoke

Smoke emissions are compared as shown in fig.5. It is noticed that the smoke emission is 8 BSN in diesel fuelled engine where as it is 5.7 BSN in Oxy hydrogen supplemented engine. The reduction of hydrocarbon fuel consumption attributed for the lesser smoke of about 22%.

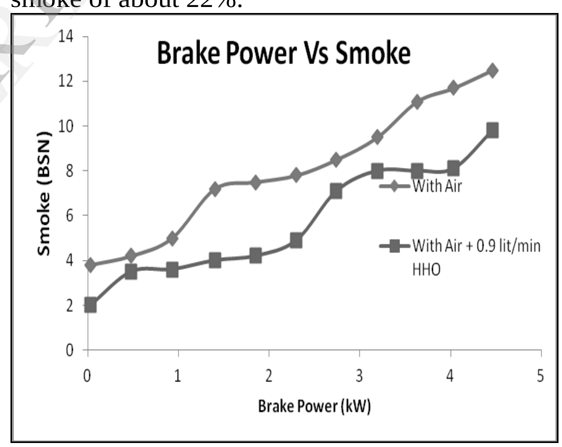

Fig.5 Variation of Brake Power with Smoke.

3.5 Carbon monoxide, Hydrocarbon and Carbon dioxide emissions

The Emissions of Carbon monoxide, Hydrocarbon and Carbon dioxide are shown in Fig 6, Fig 7, and Fig 8.The carbon dioxide emissions are seen quite higher of about 11% in Oxy hydrogen supplemented fuel than diesel fuelled engine. This is due to the presence of Oxygen atoms in HHO which prevents the incomplete combustion.

ISSN: 2278-0181
Vol. 2 Issue 6, June - 2013

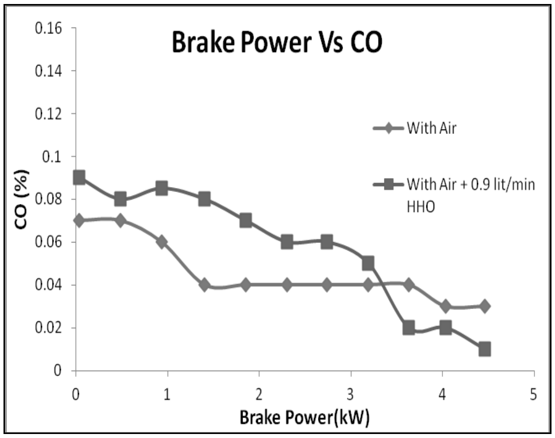

Fig. 6 Variation of Brake Power with CO

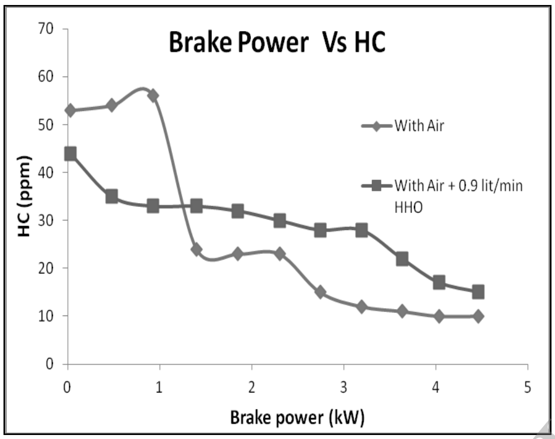

Fig 7 Variation of Brake Power with HC

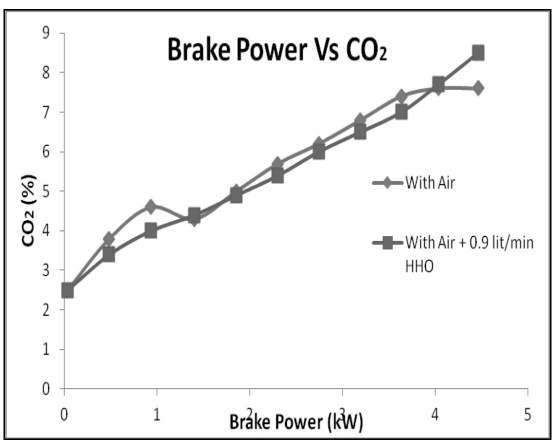

Fig 8. Variation of Brake Power with CO2

4.Conclusions

Based on the above results and discussions ,the conclusions are drawn.

1. At full load, Brake thermal efficiency increases when Oxy hydrogen is added as a fuel in the diesel engine at the flow rate of 0.9 lit/min which is due to the better mixing of HHO with air that enhances the combustion quality of the air fuel mixture.
2. At full load, The Specific fuel consumption is reduced about 31% in HHO supplemented diesel engine than the normal diesel engine.This is due to the enhancement of combustion quality of air fuel mixture.
3. There is 15% of reduction in NOx emission in HHO supplemented diesel engine since the combustion product of HHO is water(g) that decrease the peak temperature inside the combustion chamber.
4. Smoke emission is reduced about 22% in HHO supplemented Diesel engine since the presence of carbonaceous matter is less than the normal diesel engine.
5. In case of CO_2 emission,it is seen quite higher of about 11% in HHO supplemented diesel engine. This is due to the presence of Oxygen atoms in HHO which prevents the incomplete combustion.

6.References

[1] Internal combustion engines, K.K.ramalingam, Scitech publications (India) Pvt.Ltd.
[2] An Experimental investigation on hydrogen as a dual fuel for diesel engine system with exhaust gas recirculation technique,N.Saravanan,G.Nagarajan,K.M.Kalaiselvan,C. Dhanasekaran,Renewable energy 33(2008) 422-427.
[3] An experimental investigation on DI diesel engine wsith hydrogen fuel, N.Saravanan,G.Nagarajan,S.Naranasamy, Renewable energy 33(2008) .
[4] An expertimental investigation of hydrogen enriched air induction in a diesel engine system, N.Saravanan,G.Nagarajan, International Journal of Hydrogen energy 33(2008).
[5] Hydrogen engine: research and development(R&D) programmes in Indian Institute of Technology(IIT),Delhi,L.M.Das,International Journal of Hydrogen energy 27(2002).