Effect of supply of HHO gas on the performance and emission characteristics of diesel engine.

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Abstract : This study has been undertaken to investigate the basic properties of gas generated through electrolysis of water and then used this gas in the bike as a fuel with diesel by mixing it with air. This may results in the increased mileage of bike 30 to 60% and reduce the polluting contents from the exhaust gases. It is actually an electrolysis unit having high grade stainless steel/graphite/semiconductors as electrodes in a closed container and mixture of distilled water & suitable ionic solution (KOH or NAOH) as electrolyte. Power for electrolysis is taken from an additional battery provided (12V).This battery can be recharged from a dynamo/alternator/motor provide by engine.

***Index Terms* – Electrolysis, Mileage, electrode, ionic solution.**

I. INTRODUCTION

Alternate fuel is important and it should be fossil one. Actually we spend one third of our income for our vehicle fuelling and the vehicle gives harmful decomposed materials like CO, NOx , HC,etc. in the form of smoke. These materials are all affects the engine performance and pollutes the environment. Water is one of the free recourses and by applying the technique, it can be converted into hydrogen with oxygen, its chemical term is HHO and in general "Free Energy".

To avoid these drawbacks, some level of HHO is mixed with filtered air, which is after the air filter system and before the engine in taken system of the vehicle. This mixed HHO ignites releasing the extra electrons into the igniting fuel and thus the added extra energy from the HHO leads cent percent of complete burning of the fuel. HHO is popular and common gas produced from electrolysis. The outcome get by this project is that there is increasing in mileage of the vehicles up to certain percentage according to their specification & running condition of vehicle & also there is a reduction of harmful decomposed material up to certain percentage. There is increasing in the engine lubricating oil life up to certain service timing & there is also reduction in suspended carbon particles inside the engine combustion chamber. From the above description we can say that the fuel efficiency and vehicle performance are increased. The emissions of harmful and toxic gases are reduced up to some percentage. This is the safest method to give clean & healthy environment to the next generation people by installing this HHO model in all two and four wheelers vehicles[6-8].

Bysveen[1] (2007) reported about the working characteristics of S.I engine when CNG and HCNG were used as a fuel. The engine used for his experiments was a three-cylinder, single spark plug, 2.7 litre Zetor Z4901 originally used for stationary applications. He rebuilt the engine for natural gas use by reducing the compression ratio from 17:1 to 11:1. He equipped the test engine with K-type thermo couples in the intake manifold, in the cooling water system and in the exhaust. He employed hydraulic dynamometer for loading the engine. He studied the sensitivity in spark timings for the fuels and the engine in the range of 51o to 251o BTDC. The CNG fuel used for this work consisted of about 99.5% vol. of CH4, and the HCNG consisted of a mixture of 29% vol. of hydrogen. His results showed that the brake thermal efficiency was considerably higher using HCNG than using pure CNG. This effect was most pronounced for the high engine speeds.

In general, he observed less production of unburned hydrocarbons when adding hydrogen to the CNG for a given excess air ratio. He reported that this was due to the fact that the lean limit for pure methane air mixtures was much richer than the lean limit for hydrogen-enriched methane air mixtures. With H2 addition, a smaller quenching zone resulted; this enabled the flame to propagate closer to the walls. He further observed that the addition of hydrogen to methane air mixtures increased the combustion speed and the combustion temperatures; it led to increased NOX emissions compared to pure natural gas.

Mohammed[2] et al (2011) investigated on the performance and emission of a CNG-DI and spark-ignition engine when a small amount of hydrogen was added to the CNG using in-situ mixing. They set the injection timing to 30o BTDC, kept the air fuel ratio at stoichiometric, and the ignition timing to maximum brake torque. They performed experiments at 2000, 3000, and 4000 rpm of engine speeds with WOT conditions. From their results, it was interpreted that the introduction of a small amount of hydrogen improved the engine performance, brake specific energy consumption, and cylinder pressures. The CO emission of the engine got decreased until the engine speed reached 3000 rpm and then started to increase with the increase in engine speed. They stated that this was mainly due to increase in completeness of combustion process and sufficiency of oxygen. At high speeds, the CO emissions tended to increase due to retardation in timing which also resulted in poor combustion. For all rates of hydrogen THC tended to decrease. They attributed this to decrease in the carbon fraction in the fuel blends and the increase in combustion temperature due to increase in H2 fractions.

Bhaskar[3] et. al (2010) reported about the effects of gaseous fuel additives on a pilot ignited, directly injected natural gas engine. The additives used in their investigation were propane, ethane, hydrogen and nitrogen. They used a single cylinder test engine equipped with a prototype fuelling system for their study. They controlled the diesel and natural gas injection processes by electronic control operated multi-fuel injector. They equipped the engine with a custom air-exchange system to ensure that the charge conditions were independent of variations in fuel composition and injection timing. They prepared the nitrogen, ethane, and propane fuel blends using bottled gas combined with commercially distributed natural gas in large volume storage tanks. They left the blends in the storage tanks for at least 48 hours to ensure that they were fully mixed before being supplied to the high pressure gas compression system for supply to the engine. To avoid condensation of the heavy hydrocarbons, the kept all concentrations below the saturation partial 53 pressure at all times. They selected mid-load condition for their investigation to compare the effects of the various fuels. For their study, they controlled the combustion timing by varying the timing of the start of the pilot fuel injection process. The timing of the gas start-of-injection (GSOI) was fixed at 1.0 ms after the end of the diesel injection. The 50% IHR was used as the control variable representing the combustion timing. They adjusted the start-of-injection timing for the different fuel blends to maintain the 50% IHR at the specified value. For all rate of the gaseous fuel. They fixed pilot quantity at 5% of the total fuel on an energy basis; this amounted to approximately 6 mg diesel/cycle for all the conditions tested. The pilot diesel and gaseous fuel rail pressures were constant at 21 MPa for all the tests. Their results showed that the hydrogen addition to the fuel resulted in an increase in ignitability for the gaseous fuel, and a corresponding reduction in ignition delay. The effects of ethane and propane were similar to those of hydrogen.

II. THEORETICAL BACKGROUND

2.1 Properties of HHO gas[5]:

There are many unique and unusual properties that HHO Gas possesses. Below is a list of some of the properties.

- Gas is odorless, colorless and lighter than air.
- In the production of HHO Gas, there is no evaporation process at all, the electric energy used being insufficient for evaporation.
- The variable character of the energy content of HHO Gas is evidence that the gas has a unique structure with a chemical composition including bonds beyond those of valence type.
- HHO Gas does not follow the fundamental PVT Law for gases.
- HHO Gas demonstrates an anomalous adhesion to gases, liquids and solids. HHO Gas bonds to gaseous fuels (such as natural gas, magne gas fuel, and others) and also to liquid fuels (such as diesel, gasoline, liquid petroleum, and others).
- Santilli describes the creation of the gaseous and combustible HHO from distilled water at atmospheric temperature and pressure via a process structurally different than evaporation or separation, which suggests the existence of a new form of water.
- HHO is described to have the structure H-O-H where represents the new molecular bond and the conventional molecular bond. The transition from the conventional H-O-H configuration to the new H-O-H species is explained as being a change of the electric polarization of water caused by the electrolyses.

2.2 HHO generation with Wet & Dry Cells:

First, wet cells are used to produce HHO gas. Different electrolytes were used for the process such as Sodium chloride (NaCl), Sodium carbonate (Na_2CO_3), Hydrogen chloride (HCl), Potassium hydroxide (KOH). Comparison is mentioned in following table

Table 2.1. Comparison of different electrolytes

Name of electrolyte	Quantity of Electrolyte	Quantity of water	Process parameters	Remarks
NaCl	50gm and 100 gm	1 litter	12 V, 12 amp	• Green thick layer is formed after 40 minutes of the experiment which leads to reduce generation rate of HHO.
Na_2CO_3	50gm and 100 gm	1 litter	12 V, 12 amp	• Foam is formed after 20 minutes of experiments and HHO production rate decreases gradually.
HCl	100 ml	1 litter	12 V, 12 amp	• Production becomes faster and production rate is also increased. • High heat generation leads to evaporation of water.
KOH pellets	50 gm	1 litter	12 V, 12 amp	• High production rate, low cost, low heat generation.

Steel plates were used as electrode for HHO generation process. Several problems were faced during the experiment such as corrosion of plates causes frequent replacement, low production rate of HHO gas, process rate is slow, consumes more power and causes steam generation due to plate heating.

Fig. 2.1. Electrolysis with NaCl as electrolyte

Fig 2.2 Electrolysis with Na_2CO_3 as electrolyte

Fig. 2.3 Electrolysis as HCl as electrolyte

HHO gas can also be produced with dry cell. Hydro tech Dry cells are basically having design improvement over wet cell. Two stainless steel electrodes are placed in the HHO cell and are connected with pulse with modulator circuit by external wiring. HHO cell is filled with electrolyte solution which contains mixture of water and electrolyte. The electrolytes used in the electrolytic solution are sodium hydroxide, potassium hydroxide and baking soda. Electrodes are dipped in the solution for passing the current. The bubbler is simply a container half filled with water. HHO gas is fed to the bottom of the bubbler with a hose from your electrolyte tank and allowed to bubble through the water. Dry cell generates less heat than wet cell because here currant runs in the dry cell chamber only. HHO Dry cell are more slim and compact for any HHO output required. Dry cell models are leak proof and long life designs.

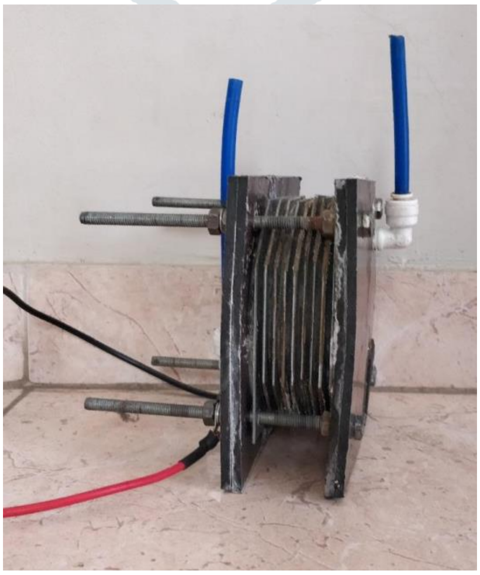

Fig. 2.4. Dry Cell

III. EXPERIMENTAL SET-UP

Diesel-HHO engine set up consists of four stroke 500 CC, single cylinder engine. The engine is attached to the bed of the Diesel-HHO engine set up by the help of fasteners. The output of HHO gas is connected to hose pipe after the air filter and injected inletpipe. The hydrogen generated at cathode is fed to the inlet manifold that is in air hose pipe of the engine, then this gas mix with the coming air from the air filter when the vacuum is created by the piston movement from TDC to BDC. As the ho hydrogen or HO gas mixed with air then it goes to engine cylinder during suction stroke. During compression stroke, HHO + air will mix with diesel. The hydrogen explosion is so fast that it fills the combustion cylinder at least 3 times faster than the diesel explosion and subsequent ignites the diesel from all directions.

Fig. 3.1 Experimental Set-Up

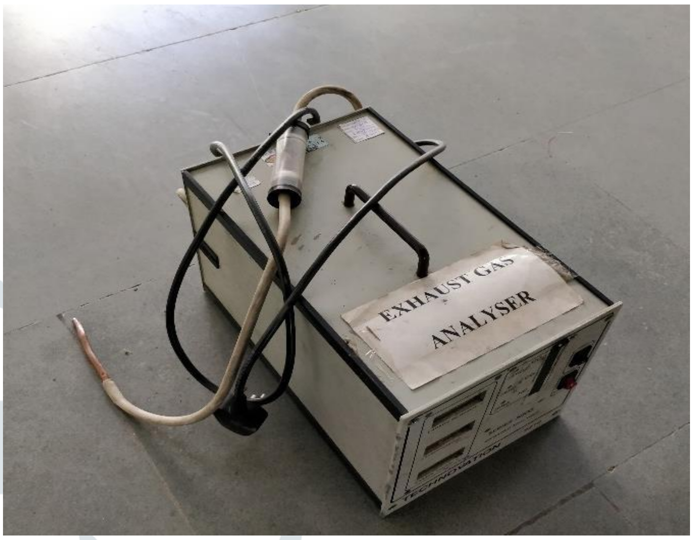

Fig. 3.2 Exhaust gas Analyzer

Experiment is performed without supply of HHO gas, with HHO gas supply by opening full valve and HHO gas supply by opening half valve. Engine specifications are mentioned in following table.

Table 3.1 Engine Specifications

Engine Type	4-Stroke, 1-Cylinder
Fuel	Diesel
Bore	80 mm
Stroke	100 mm
Rated Power	3.7 kW
Rated Speed	1500
Method of loading	Eddy Current

IV. RESULTS AND DISCUSSION

4.1 Brake Thermal Efficiency:

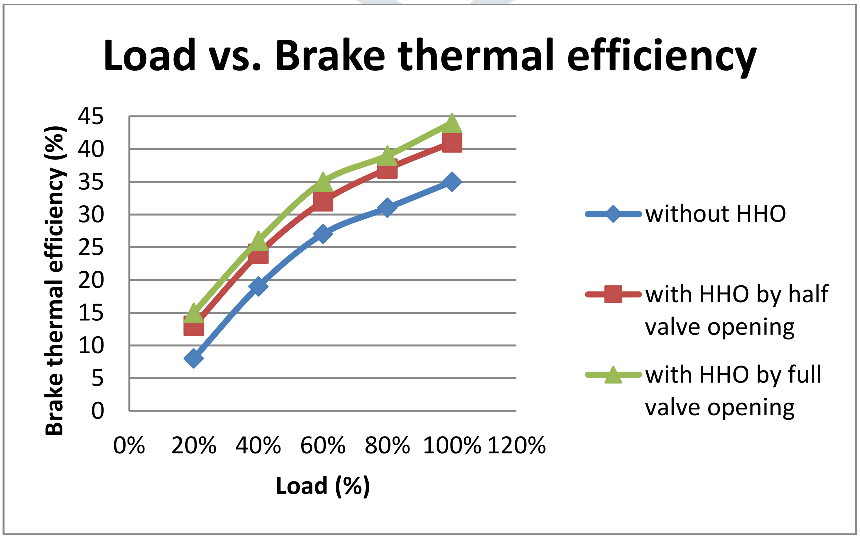

Fig. 4.1 Load vs. brake thermal efficiency

As shown in fig. 4.1, brake thermal efficiency increases with increase in load on the engine as engine has poor part load efficiency. It is also mentioned in the chart that with HHO gas supply, thermal efficiency of the engine increases. This may be because HHO has high and quick explosion which provides complete and homogeneous combustion. There is a significant rise in thermal efficiency with supply of HHO by opening half valve rather than that with full valve opening. Thermal efficiency is increased by 62% at no load condition due to HHO gas supply by opening half valve and that is increased by 87% at no load condition due to HHO gas supply by opening full valve.

4.2 Brake Specific Fuel Consumption:

It is clear from the fig. 4.2 that, with increase in load the brake specific fuel consumption decreases. The BSFC may increase for overloading condition. The minimum BSFC is at 80% loading condition with HHO gas supply by opening full valve. BSFC is reduced by around 50% by supplying HHO with half valve opening compared to without supply of HHO gas.

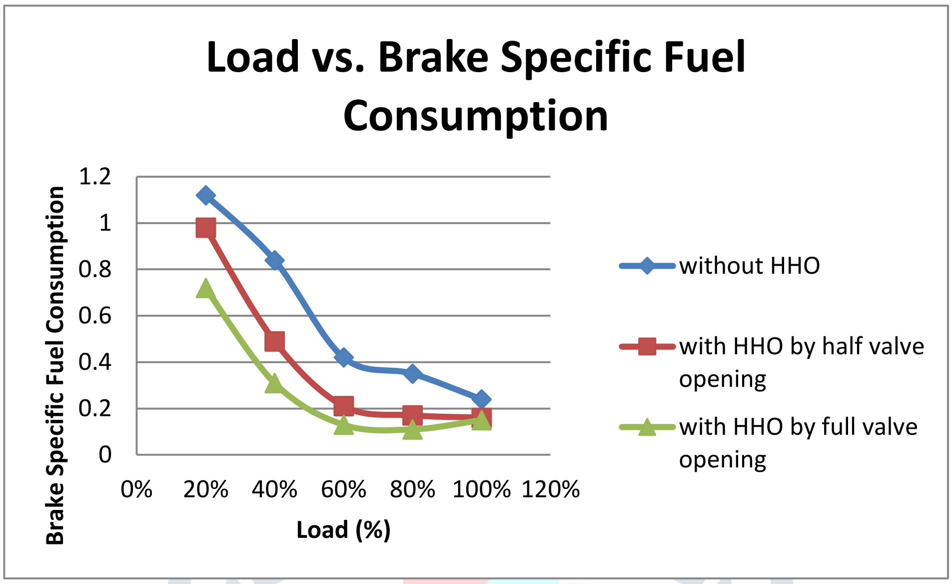

Fig. 4.2 Load vs. Brake Specific Fuel Consumption

4.3 CO Emission:

From fig. 4.3, it is seen that with rise in loading condition CO emission increases. It is also seen that there is no significant change in CO Emission for HHO gas supply with half opening and HHO gas supply with full opening. CO emission is reduced by 45% at 60% loading condition with HHO supply by half opening compared to base condition.

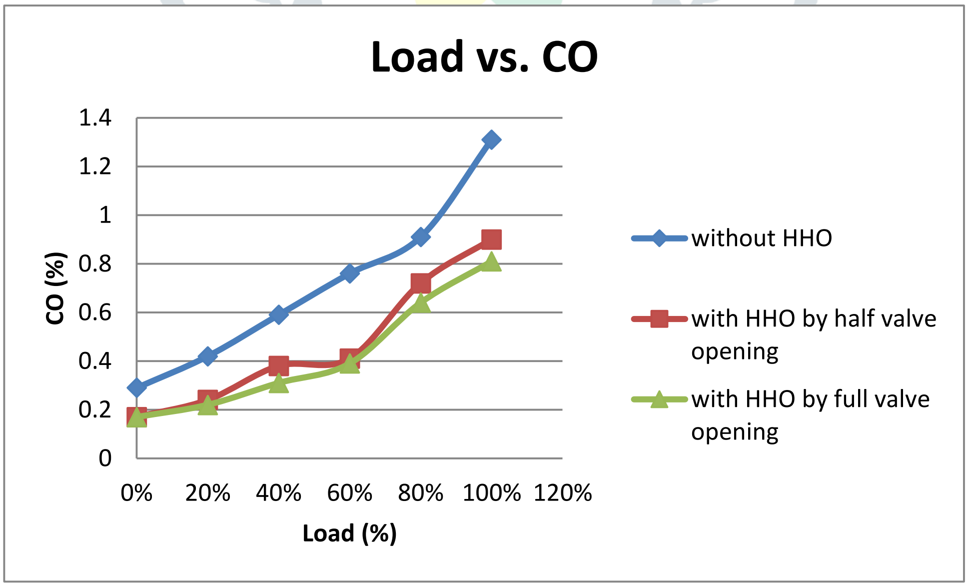

Fig 4.3 Load vs. CO Emission

4.4 HC Emission:

From fig. 4.4, it is derived that with increase in loading on the engine HC emission increases. HHO supply with half valve opening line and HHO supply with full valve opening line are almost adjoining with each other. Significant decrease in HC emission is achieved with HHO supply at half valve opening condition compared to base condition.

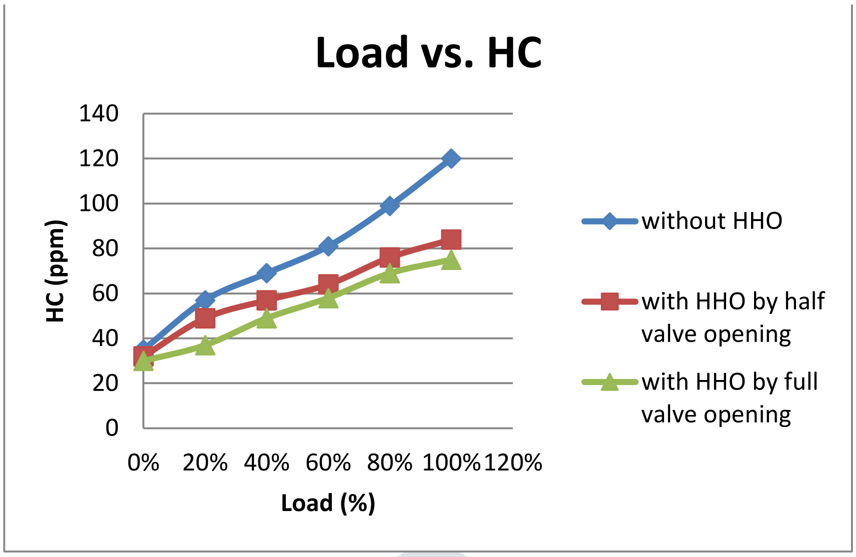

Fig. 4.4 Load vs. HC Emission

V. CONCLUSION

The impacts of using a small amount of H2/O2 mixture as an additive on the performance of a four-cylinder disel engine were evaluated. Hydrogen is generated by on board production with electrolysis process. Supply of HHO gas (Brown gas) can be regulated by providing flow control method. Dry cells are better than wet cells due to certain limitations of the wet cells. HHO gas have better combustion characteristics compared to diesel improves performance and emission characteristics of diesel engine. Effect of HHO gas on performance and emission characteristics of diesel engine can be evaluated.

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