Performance and Emission Characteristics of Oxy Hydrogen Gas on a Three Cylinder Four Stroke Petrol Engine

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Abstract: ***Petroleum crisis is a great bottleneck in the supply of crude oil resources to an economy which calls for an alternative and indispensable fuel. But alternative options to petroleum fuel are having many restrictions. An electric car has a limited range and long charging time and compressed air driven cars cannot be used where high torque is required or using hydrogen as fuel requires very costly storage equipments. Amongst many alternative fuels available oxy hydrogen gas is under study in this research workbox hydrogen gas, which is enriched mixture of hydrogen and oxygen bonded together molecularly and magnetically, this producer gas can emerge as best alternative fuels in the upcoming future. Oxy-hydrogen gas is produced by electrolysis of water using caustic soda or KOH as a catalyst. Presence of oxy-hydrogen gas during combustion process decreases the 'brake specific fuel consumption' and also increases the 'brake thermal efficiency'. Water is one of the by-products of the combustion process which also decreases the temperature of the combustion process. It is safe to use 'oxy-hydrogen gas' as it cannot be stored but can be produced within few seconds after ignition and can be switched on and off. All together it has been observed that the blend of 'oxy-hydrogen gas' and petrol instead of only conventional fuel improves the performance of the engine up to 20% and consequently reduction in emission gases such as Carbon Monoxide and Hydrocarbons.***

Keywords: 3 cylinder Petrol engine; Electrolysis; Oxygen Enriched hydrogen-HHO gas; emission characteristics

1. Introduction

At the present day, where the supplies of the fossil fuels are decreasing and increase in the concentrations of atmospheric carbon dioxide as well as atmospheric pollutants are some of major challenges to the modern society. The scientific community is addressing these problems by an attempt to replace fossil fuels with cleaner and renewable sources of energy such as solar powered vehicles, electric cars. But we have seen that this are either non-reliable, costly or lags the technical advancement and convenience which is provided by the petroleum fuel vehicles. So the idea is not to compete with petroleum fuels but to increase the life of petroleum fuels to exist longer in this ever demanding automobile industry. Every buyer has a mind set to have a vehicle with great looks, good performance and high efficiency. But unfortunately, even with the latest technology, it is difficult to achieve the perfect balance between performance and price. So in order to conserve petroleum fuels for future and to eliminate the aforementioned limitations, there is a need of alternative and innovative fuel.

The oxy-hydrogen gas is obtained by the simple process of electrolysis of water, which has high calorific value which can be used in addition to petrol. In this research work, the oxy-hydrogen gas is used in four stroke petrol engine for better performance and lower emission values. The

1.1 Properties of Oxy-Hydrogen Gas

Firstly, as the name says it is a mixture of hydrogen and oxygen gases, it can be said as the fourth form of water which is made up of "magnecules" of hydrogen gas (HH) connected to lone oxygen atoms (O) by "magnecular" bonds. It has good properties for being qualified as a fuel, for a stoichiometric mixture at normal atmospheric pressure, auto-ignition of oxy hydrogen gas occurs at about 570°C (1065°F). The minimum energy required to ignite such a mixture with a spark is about 20 micro joules. At normal temperature and pressure, 'oxy-hydrogen gas' can burn when it is between about 4 and 94% hydrogen by volume , the water is the only product after the ignition , so there is no possibility of any harmful particles after burn. The amount of heat energy released is independent of the mode of combustion, but the flame temperature may vary. The maximum temperature of about 2800°C is achieved with a pure stoichiometric mixture, about 700°C hotter than a hydrogen flame in air. Oxy-hydrogen gas has very high diffusivity. It has ability to disperse in air, which is considerably greater than gasoline and it is advantageous for mainly two reasons. Firstly, it adds the mixability with fuel and air, which makes the mixture homogenous and secondly it adds to the safety during any leakage as it has very low density, it can disperse rapidly. The storage of this gas is very difficult, but the production can be controlled, so there is no need of any storage tank.

1.2 The Difference between Oxy-Hydrogen and Hydrogen Gas

The oxy-hydrogen gas is also called as Brown's gas which comprises (by volume) of two parts of hydrogen gas and one part of oxygen gas, same as the proportion of the water or the water vapour, but Professor Yull Brown and Sir William Rhodes discovered that it is very different. HHO is not oxygen plus hydrogen, they are not separated after electrolysis, and it is a di-atomic structure that is the molecules of both gases (Oxygen and Hydrogen) form molecules of two atoms each.

1.3 The Electrolyser

The construction of electrolyser can vary, but in this experiment High Density Polymer (HDPE) is used as it is non-corrosive and high strength to density ratio. The electrolysis is done within the electrolyser, thus it contains terminals for power supply which is done by the car's battery. It is also equipped with an adjustable air bubbler, to control the flow of air. Inside the electrolyser, the electrodes inside the device are made from stainless steel (ss) 15 gauge wire of 316L grade which is commonly available, which is spiralled and glued around a core of acrylic or PMMA. Never use aluminium or copper wires, these are great electricity conductors, but they would be destroyed by the electrolysis process. As for the electrolysis distilled water is used and filled up to $3/4^{th}$ of the height, the electrolyte preferably is KOH (Potassium Hydroxide) for better conduction and it is generally about 2-3% of the total water filled . It is also equipped with air bubbler adjuster and electric terminals for power supply as well as the outlet valves.

The chemical reactions that take place inside the electrolyser when assuming ideal faradic efficiency, the amount of hydrogen generated is twice the number of moles of oxygen and both are directly proportional to the total electrical charge conducted by the solution is:

Cathode (reduction): $2\ H_2O + 2e^- \rightarrow H_2 + 2\ OH^-$
Anode (oxidation): $4\ OH^- \rightarrow O_2 + 2\ H_2O + 4\ e^-$
Overall reaction: $2\ H_2O \rightarrow 2\ H_2\ (g) + O_2\ (g)$

The electrolyser is arranged in line with the 'back fire protection tube' for the safety backup, it is filled with almost half by volume with normal or distilled water. as the name says, it provides the safety during any misfire from the engine, if occurs, as the HHO gas is highly flammable and during the combustion of the engine, if any accident happens then the gas will back flow to the electrolyser, to avoid this situation it has to pass through the back fire protection tube which will cease the fire and prevents, thus it is an important measure of safety which is used.

2. Experimental Setup

The setup does not require any permanent modification in the engine as such. We have used two identical electrolyser connected in series, to obtain necessary amount of HHO gas for the used engine. The electrolyser needs to be mounted flat and level, preferably under the hood in the engine's firewall for the convenience. the outlet valves of both the electrolyser can be connected by the Y connecter and then it is piped to the back fire protection which also can be mounted in the engine bay and it needs to be steadily fixed, as the tube is filled with water thus the HHO can be seen travelling in the form of bubbles to the upper side where the outlet from the tube is provided. the HHO gas is now fed directly into the engine manifold where the combustion takes place, the manifold needs to be drilled and installed with pipe fitting so that it can be screwed back when not needed and easily removable . the electrolyser is designed to operate on 6 volts as two electrolyser I connected in series, the terminals made are from brass for better conduction, the negative terminal is directly connected to battery's negative whereas the positive terminal is equipped with a fuse , so that can cut off the supply during the overload or short circuit , in the same line the relay switch is connected , the function of this switch is that it starts the current supply only after the engine gets started , an on/off switch is also provided in the drivers cabin for turning off this setup when not required . Usage of multi grade 2.5 mm wire is preferable and proper and tight connections need to be made. For piping EPDM (Ethylene Propylene Diene Monomer) pipes are used of 6mm or 8mm, as these pipes are elastomers they have outstanding properties of resisting heat and electricity.

2.1 Technical Specifications of the Engine

Engine

- Engine model/name: F8/Maruti 800
- Displacement: 796 cc (49 cu in)
- Valves per cylinder: 2
- Number of cylinders: 3 inline
- Fuel type: Petrol
- Power: 37 HP at 5000 rpm
- Rpm limiter: ~7000 rpm
- Torque: 57 Nm at 2500 Rpm

Transmission

- Transmission type: Manual
- Gears: 4-speed gearbox

2.2 Engine Layout Diagram

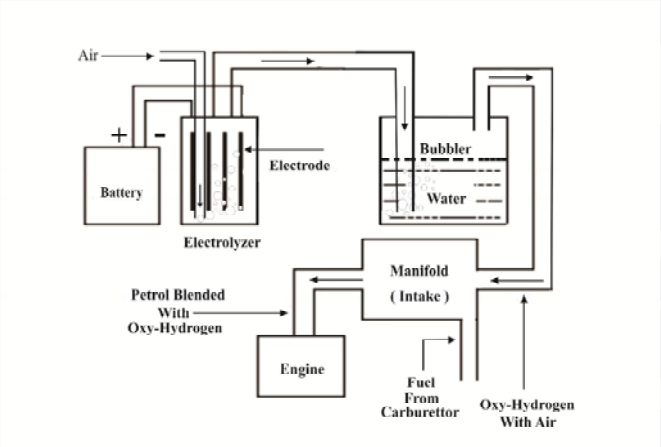

Figure 1: The layout of the engine equipped with HHO electrolyser and connections

2.3 Tuning the Engine with HHO

When the engine is started and settled into its idle, then the HHO is switched on, the engine tends to shake because of the presence of HHO gas, which lowers rpm than the idle, the air screw is let open to the full, which increases the engine rpm about1300, which is the maximum rpm value that can be get by air screw, now the rpm is reset back by idling screw to maintain the ideal rpm. The tuning is required because the engine gets dual fuel (Petrol & HHO), which makes the condition of rich mixture than usual, so to maintain the proper air-fuel ratio, the amount of air is increased.

3. Performance and Emission Characteristics

The improvement in the performance and emissions are significant, as expected, the engine now using leaner fuel saves fuel and the combustion efficiency is increased, To check the rate of oxy hydrogen gas generated with respect to current, a loss of weight of electrolyser is noted forgiven period of time and current. Current passing through electrodes is increased from2 ampere to 2.5 ampere with increase in the time for which the current is flowing through electrolyser, weight of electrolyser decreases. Larger the weight loss larger is the gas generation weight. Also with increase in amplitude of current the rate of generation increases. For larger gas generation it is possible to increase the amplitude of current as well. As the engine keeps on consuming the oxy hydrogen the level of electrolytic solution in the electrolyser decreases which further decreases the weight of the electrolyser. The design of electrolyser was tested on the enlisted engine, technical specifications of which are listed earlier in this article. The operating characteristics of the engine showed improvements in the emission and performance, the emission testing is done by 'AVL Di-gas 444', the exhaust gas is fed into the testing machine, the parameters measured are the percentage of Carbon monoxide (CO) and the numbers of Hydrocarbon(HC) in PPM, the tests were conducted before and after the HHO fitment.

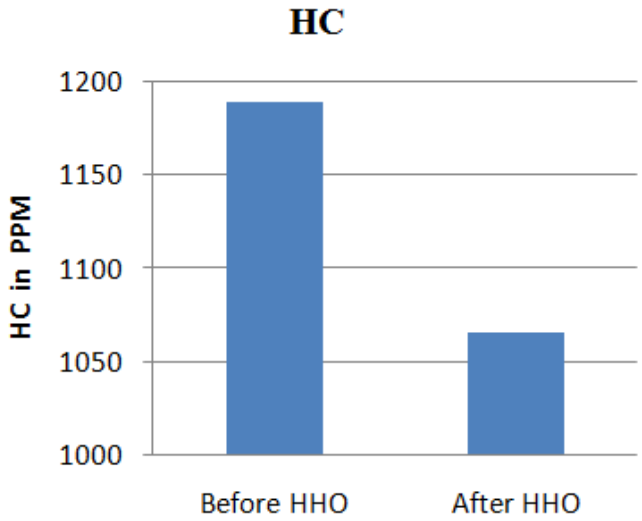

Figure 2: Reduction of hydrocarbon measured in PPM (Parts per Million)

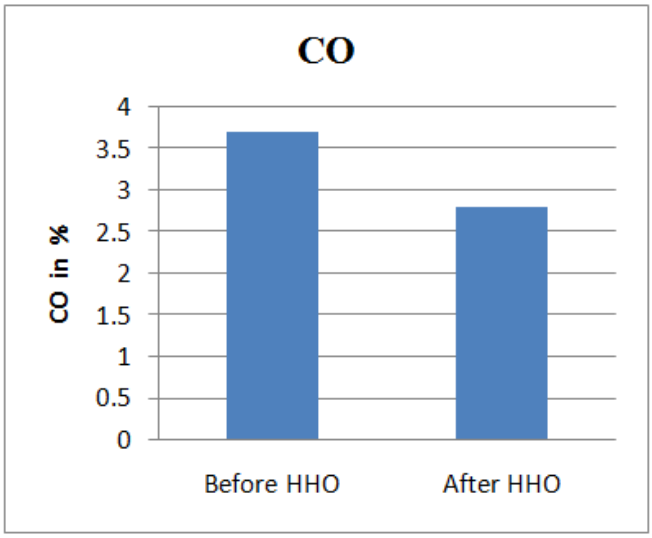

Figure 3: Reduction in Carbon Monoxide gas measured in percentage by volume

The emission test showed the positive results due to increase in efficiency of the combustion, the burning of the fuel was more efficient and thus lesser unburnt hydrocarbons (Figure 2) as well as lower percentages of CO gas (Figure 2). In the long run of testing the increase in fuel efficiency also showed increase of about 18 to 20 percent. From the aforementioned discussion, it is clear that there is definitely improvement in the performance of the engine when the engine is run on the blend of 'oxy-hydrogen' and conventional fuel, 'petrol' here. Further the presence of 'oxy-hydrogen' in the combustion chamber supplies additional oxygen which leads to completed combustion of the air fuel mixture. Thus the pollution is greatly controlled as the products that would be produced due to burning of conventional fuel and are reduced due to complete combustion. Water vapour is one of the by-products of the combustion process with the blend of 'oxy-hydrogen' and petrol. Presence of water in the combustion chamber also decreases the temperature of the combustion chamber. Thus there are little chances of 'detonation' which is the major factor during increased power delivery of any engine. Also formation of water vapour does not allow deposition of the carbon on the cylinder wall and keeps the combustion chamber clean which further increases combustion efficiency.

4. Conclusion

- Lowered values of CO and HC in exhaust gas as well as more efficient combustion leads to lower amount of CO_2 gas as well.
- Higher efficiency, gain up to 15% is noted in the consumption of fuel.
- Lowered the temperature of engine thus longer life of coolant and better performance figures.
- Reliable method of fuel saving.

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