FABRICATION AND PERFORMANCE TESTING OF 'HYDROXY GAS GENERATOR'

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ABSTRACT:

In the past few years automotive companies have been searching for technological advantages to increase fuel millage in order to protect the environment, while still providing an enjoyable driving experience for their customers. With gas prices on the rise, the average American wants a car that can do everyday activities whilst spending the least amount of fuel possible.

The basic properties of gas generated through electrolysis of water and then used this gas in the 800cc engine as a fuel with petrol by mixing it with air. This results the increased mileage of engine 30 to 60% and reduce the polluting contents from the exhaust gases. The threat posed by climate change and theist riving for securities of energy supply are issues high on the political agenda these days. Governments are putting strategic plan motion to decrease primary energy use, take carbon out of fuels and facilitate modal shifts. Taking a prominent place in these strategic plans is hydrogen as a future energy carrier. Energy stored in hydrogen would be available at any time and at any place on Earth, regardless of when or where the solar irradiance, the hydropower, or other renewable sources such as biomass, ocean energy or wind energy was converted. Hydrogen gas combined with the standard air/fuel mixture increases the mileage. This form of alternative fuel is provided by a hydrogen generator mounted in the vehicle. Once set up is ready, the hydrogen gas (fuel) will be produced from water, an electrolyte compound, and electricity supplied from a battery provided Here we are designing a mixed fuel 800cc engie.ie in a conventional SI engine we are incorporating traces of hydrogen along with gasoline in order to minimum consumption of gasoline as well as to increase the power of vehicle. Here in addition, a hydrogen generating unit is made to produce hydrogen .It is actually an electrolysis unit having high grade stainless steel plates 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 provided on the vehicle.

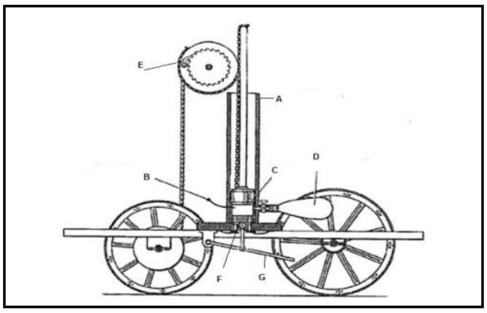
Keywords:
Hydrogen, Electrolysis

1. INTRODUCTION:

Introduction to Hydrogen Engine:

In the beginning, all engine experiments were designed for burning a variety of gases, including natural gas, hydrogen, and propane. There had been many investigations on hydrogen enriched combustion in internal combustionengines. Rivaz (1807) of Switzerland invented an internal combustion engine with electric ignition which used the mixture of hydrogen and oxygen as fuel. He designed a car for his engine. This was the first internal combustion powered automobile (Bruno 1996, Eckermann 2001, Dutton 2006). Later, he obtained French patent for his invention in 1807. The sketch of his engine taken from his patent is shown in Figure.

Cecil (1820) described a hydrogen engine in his paper entitled "On the application of hydrogen gas to produce a moving power in machinery; with a description of an engine which is moved by pressure of the atmosphere upon a vacuum caused by explosions of hydrogen gas and atmospheric air." In this document, he explained how to use the energy of hydrogen to power an engine and how the hydrogen engine could be built. This is probably one of the most primitive inventions made in hydrogen-fueled engines. In 1863, Lenoir made a test drive from Paris to Joinville-le-Pont with his hydrogen gas fueled one cylinder internal combustion engine Hippo mobile with a top speed of 9 km in 3 hours (Energy library 2014).



It is a very well-known fact that fossil fuels are used as the source of energy for the internal combustion engines. However, due to their higher depleting rates and increasing prices, a number of researchers have dedicated their research work on investigating alternative sources of energies for the internal combustion engines. Some of the researchers have focused on the methanol and organometallic (MnO2) fuels, vegetable oil, natural gas, neem oil, methyl ester, HHO gas etc. as alternative fuels or additive fuels. Water is most abundant element on this earth and recently used as a free energy source and has been introduced to the automobile industry as a new source of energy named as Brown Gas (HHO). It is used as a supplementary fuel in petrol, diesel, CNG engines etc. to improve the power production and to reduce the hazardous gases such as CO2, HC, NOx, CO etc. in the emission.

Hydrogen is widely acknowledged as a non-polluting, renewable, and recyclable fuel. The major dissimilarity between hydrocarbon fuels and hydrogen fuel is the absence of carbon. Moreover, as compared to other hydrocarbon fuels, hydrogen has greater flame speed, faster burning velocity and wider flammability limits. This helps the engine to complete the combustion process and to run on very lean mixtures which results in less unborn fuels and reduced pollutants in the emission. Hydrogen could become an important element, allowing us to accumulate and transfer energy in a clean way. Hydrogen can be used in cars as a fuel additive which increases the combustion efficiency of the fuel-air mixture. H2 gas ensures noteworthy ability as a supplemental fuel to rally the emissions and performance of SI and CI engines.

The unique combustion characteristics of hydrogen that allow clean and efficient operation at low engine loads present difficulties at high engine loads. Here, the low ignition energies of hydrogen–air mixtures cause frequent unscheduled combustion events, and high combustion temperatures of mixtures closer to the stoichiometric composition lead to increased NOx production. Both effects, in practical application, limit the power densities of H2ICEs. The recent research thrust and progress on this front is the development of advanced hydrogen engines with improved power densities and reduced NOx emissions at high engine loads.

2. PROBLEM STATEMENT

With such high demand for more efficient engines, our mission is to design and create a device that will increase engine efficiency without jeopardizing its performance. Such device is an HHO Generator. This generator uses electric current (electrolysis) to yield hydrogen from water. There are two different ways to run the hydrogen into the engine. The first and most ambitious way to this is to send it through the injectors, while shutting off the fuel line. This will only be done if the system is self-sustained, meaning the car is able to run on hydrogen only. If this is not accomplished due to thermodynamic restrictions, then the hydrogen will be introduced into the combustion chamber of the engine through the intake manifold. We will attempt to make the generator compact and affordable, in order for it to be appealing to customers.

Building this generator comes with some challenges. We need to make sure that the amount of energy put into the cell to split the water molecules is less than the amount of output energy of the generator. In order to overcome this challenge we will need to make it as efficient as possible. This includes coming up with a creative design to get as much hydrogen out, with the least amount of current running through the cell. More concerns include implementing very conductive wires and metals into our system. Taking these aspects into consideration will make the HHO generator a productive addition to any internal combustion engine.

3. ELECTROLYZER ACTUAL GAS PRODUCTION AND MEASUREMENT

Fig.1 Actual Test Rig Mountings

The actual gas production is measured by using water displacement technique; it uses a graduated tube, bottle and stopwatch. The bottle with a 2-hole is filled by water as shown in the diagram. The HHO gas travels through the tubing to an inverted bottle filled with water, displacing some of the water in the bottle. The graduated tube is placed below the overflow tube and the stop watch is started at the same time. The actual gas flow rate is calculated by dividing the volume of water collected in the graduated tube by the time recorded by stopwatch.

Fig .2 Engine Set up

Petrol Engine Test:-

Table No.01 Setup Specification

Product	Engine test setup 3cylinder, 4stroke petrol
Engine	Model Maruti 800, 4 stroke, Petrol (MPFI), Water cooled, 796cc,CR 9.2
Power	27.6Kw at 5000 rpm
Type	3cylinder
Torque	59 NM at 2500rpm
Pore	66.5mm
Stroke	72 mm
Dynamometer	Hydraulic Type
Propeller shaft	with universal joints
Air box	M S fabricated with iritic meter and manometer
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type pipe in pipe
Temperature sensor	Thermocouple Type K
Temperature indicator	Digital Multi channel with selector switch
Speed Indicator	Digital with non-contact type speed sensor
Load indicator	Digital Range 0-50 Kg Supply 230VAC
Rota meter	Engine cooling 100-1000LPH, Calorimeter 25-250 LPH
Pump	Type Mono-block, 128+Head 20mHP 1.0, single phase size 25×25
Overall dimensions	W 2000× D 2750× H 1750 mm
Battery	Make Exide, Model MHD 350 06687, 12

3.1. Power measurement:

The engine power output was calculated from the measurements from torque and speed. The torque measurements were done by rotates the handle wheel on the direction of clock wise, while the engine speed was measured by using a digital meter.

Fig.3. Test-rig speedo meter

3.2 Fuel flow measurement:

Steady state measurements of the engine's overall fuel consumption were carried out using conventional mass balance system by using bottle glass filled with petrol. Fuel flow was measured by dividing fuel mass with manual timing by a stopwatch.

Fig.4. Fuel Flow Meter

3.2 Gas Analyzer:-

An exhaust gas analyzer or exhaust CO analyzer is an instrument for the measurement of carbon monoxide among other gases in the exhaust, caused by an incorrect combustion, the Lambda coefficient measurement is the most common.Chemical CO gas sensors with sensitive layers based on polymer- or heteropolysiloxane have the principal advantage of a very low energy consumption, and can be reduced in size to fit into microelectronic-based systems. On the downside, short- and long term drift effects as well as a rather low overall lifetime are major obstacles when compared with the NDIR measurement principle.

Fig.5. Gas Analyzer

3.3 Hydroxy Electronic Control Unit (HECU)

Experiments show that, when the engine speed decreases under the critical value (2500 rpm for SI and 1750 rpm for CI engines in this experiment), flow rate has to be decreased to prevent HHO occupy too much volume due to the long opening time of manifolds at low speeds. Otherwise reduction in volumetric efficiency is inevitable unless hydroxy electronic control unit (HECU) is serial connected to the HHO system (constant voltage, current and HHO flow rate), due to minimum ignition energy of HHO which is a strongly decreasing function of equivalence ratio, pre-ignition and knock occurrence is probable strongly. Also, low lean flammability limit of HHO results advantages only under dilute (lean) conditions.

Electronic control unit is designed and manufactured to decrease HHO flow rate by decreasing voltage and current. Experiments depict that voltage around 7.1 V and current around 5.4 A are suitable values for both SI and CI engines below the critical speeds. Therefore, an electronic control unit has to be designed and manufactured to set the voltage and current to desirable values when the engine speed decreases under critical readings.

4. RESULTS AND DISCUSSION

The aim of this experimental investigation is, to make a spectacular combination of anodes and cathodes in a simply adaptable ambient within the fuel system and to obtain an enhancement in combustion and reduction in exhaust emissions with electrolysis reaction without the need for storage tanks. In this experimental study, instead of pure hydrogen addition to diesel fuel, produced hydrogen gas along with oxygen (hydroxy gas, HHO, Brown's gas) is fed to the intake manifolds of a direct injection CI and a single cylinder SI engine by a HHO system and a HECU under various loads.

In this study, HHO is produced by the electrolysis process of different electrolytes (KOH(aq), NaOH(aq), NaCl(aq)) with various electrode designs in a leak proof hydrogen generator. Electrolytes are used to diminish oxygen and hydrogen bonds. HHO is used as a supplementary fuel in a four cylinder, four stroke, CI and a single cylinder two stroke SI engine without any modification and without need for storage tanks. Its effects on HC, CO emissions, engine performance characteristics and SFC are investigated.

4.1 Engine Torque

An average of 32.4% increment in engine torque is obtained with using HHO system compared to pure gasoline operation. This means an increment of 27% in average engine power during the experiments compared to pure gasoline operation is achieved. The increase in power is due to oxygen concentration of HHO and better mixing of HHO with air and fuel that yield enhanced combustion. Also, high laminar flame velocity of HHO yields shorter combustion period that provides lower heat losses, much closer to ideal constant-volume combustion which results increased thermal efficiency. The results show that the addition of HHO can significantly enlarge the flammable region and extend the flammability limit to lower equivalence ratios. At high speeds (≥2500 rpm) the weakened in-cylinder charge flow and increased residual gas fraction are formed, which block the fuel to be fast and completely burnt at low manifold absolute pressures (MAPs).

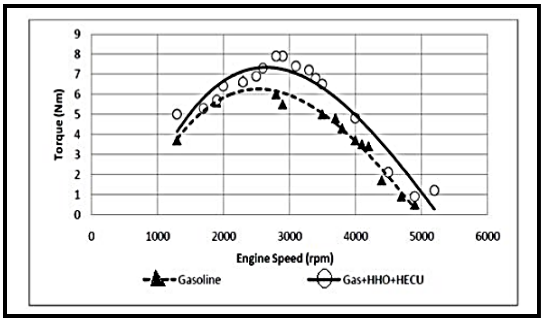


Fig.6. Variation of engine torque with engine speed

Since HHO has a low ignition energy and fast flame speed, the HHO-gasoline mixture can be more easily ignited and quickly combusted than the pure gasoline. Thus, improved torques at high speeds can be obtained. Low lean-flammability limit of HHO allows stable combustion at highly dilute (lean) circumstances. It is observed that HHO cannot have a positive effect on power output at around stoichiometric (richer) conditions. Also, due to minimum ignition energy of HHO which is a strongly decreasing function of equivalence ratio, pre-ignition and knock are inevitable. Since the energy density of hydrogen on volume basis is much lower than that of gasoline, the reduced fuel energy flow rate is attained and finally results in the dropped engine torque at low speeds. The impairments of HHO at low speeds can be turned into advantages with the aid of HECU.

4.2 Specific Fuel Consumption (SFC)

An average gain of 16.3% is achieved in SFC by using HHO system. Brake thermal efficiency is usually used to symbolize the engine economic performance. The improvement in engine brake thermal efficiency for the HHO enriched SI engine is more evidently seen at low manifold absolute pressure (MAP) conditions. The reduction in SFC is due to uniform mixing of HHO with air (high diffusivity of HHO) as well as oxygen index of HHO gas which assists gasoline during combustion process and yields better combustion. This can be attributed to that, at high speeds, the gasoline is hard to be completely burnt at lean conditions due to the increased residual gas fraction and poor mixing.

Since HHO gains a high flame speed and wide flammability, the addition of hydrogen would help the gasoline to be burned faster and more complete at high speed conditions. Also, low ignition energy of HHO-air mixture derives gasoline even to be burned safely under leaner conditions. However, at low speeds (≤2500 rpm), low lean flammability limit prevents HHO to have positive influence on combustion efficiency due to mixture requirement around stoichiometric conditions and high volume occupation of HHO causes reduced volumetric efficiency unless HECU is included to the system.

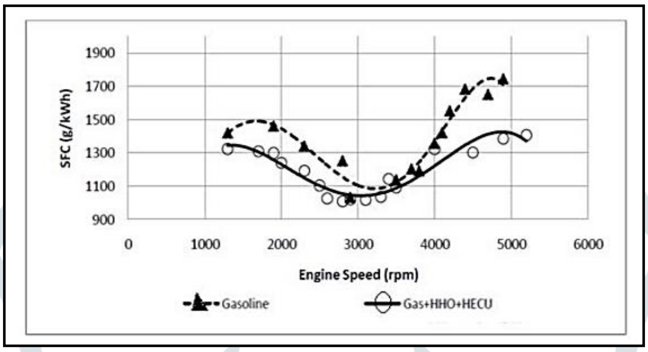


Fig.7. Variation of SFC with engine speed

4.3 Hydrocarbon (HC) Emissions

An average reduction of 6.7% is obtained in HC emissions compared to pure gasoline operation. At high speed conditions, short opening time of manifolds prevents adequate air to be taken into the cylinder and gasoline cannot be burned sufficiently. Short quenching distance and wide flammability range of hydrogen yield engine to expel less HC emissions especially under high speed conditions and low speed conditions with the aid of HECU. Besides, oxygen index of HHO yields better combustion which diminishes HC emission. At low engine speeds, due to high volume occupation of HHO, correct air cannot be taken into the cylinders which prevents gasoline to be combusted completely if HHO flow rate is not diminished at about 1.6l/min.

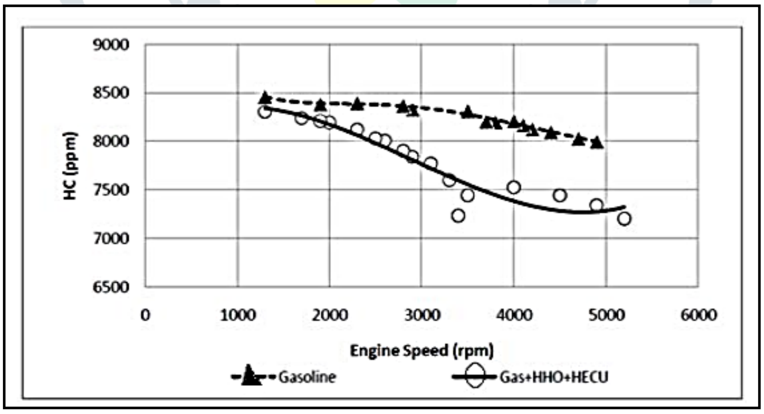


Fig.8. Variation of HC emissions with engine speed

4.4 Carbon monoxide (CO) Emissions

An average reduction of 14.4% is achieved in CO emissions compared to pure gasoline operation. Absence of carbon in HHO gas is a major reason for CO reduction. Wide flammability range and high flame speed of HHO ensure engine to be operated at low loads. The HHO-gasoline mixture burns faster and more completely than the pure gasoline. Thus, CO emission at high speed and lean conditions is effectively reduced after hydrogen addition. Since HHO contains oxygen, higher combustion efficiency is obtained and increment for CO emission is slower unless HHO flow rate is diminished to appropriate flow rate values while approaching low speeds.

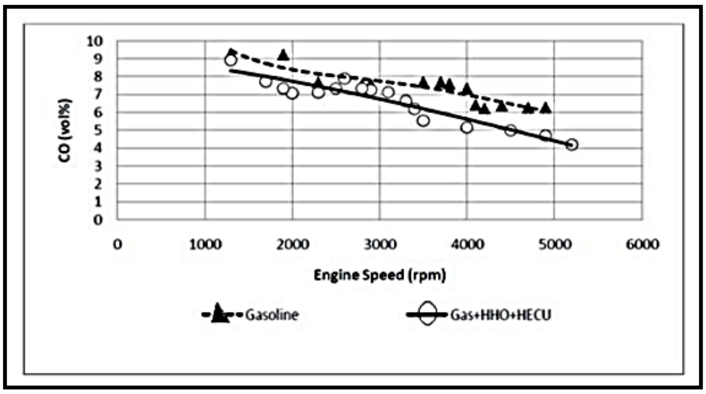


Fig.9. Variation of CO emissions with engine speed

CONCLUSION:

1. At mid and higher engine speeds, the HHO system with diesel fuel and gasoline yields higher engine torque output compared to pure gasoline fueled engine operation unless HECU is added to the system. High burning velocity and low ignition energy of HHO-air mixture minimize the effect of the weakened in cylinder charge flow and increased residual gas fraction which block the fuel to be fast and completely burnt at high speeds. Also, high burning velocity of HHO yields higher resistance against knocking which provides higher compression ratio (CR) and increased thermal efficiency. However, increased CR may cause pre-ignition and this can be minimized by direct HHO injection into the cylinder. At low engine speeds, low lean-flammability limits of HHO causes challenges at higher equivalence ratios. Due to the long opening time of intake manifold at low speeds, high volume occupation (reduced volumetric efficiency) of HHO becomes inevitable. Since minimum ignition energy of HHO-air mixture is a decreasing function of equivalence ratio till stoichiometric (richer) conditions, torque is reduced after HHO addition. A control unit has to be used to obtain appropriate electrolysis voltage and current (gas flow rate) to terminate the impairments of HHO gas at low speeds.

2. Uniform and improved mixing of HHO-air and oxygen content of HHO stimulate combustion which has a major effect on SFC by using an adequate capacity HHO system. Wide flammability range, high flame speed and short quenching distance of HHO yield gasoline and diesel fuel to be combusted completely under high speed conditions without HECU and low speed conditions with HECU.

3. High burning velocity, wide flammability range, oxygen content and absence of carbon make HHO gas an appropriate fuel addition to obtain adequate combustion which yield reputable reduction of HC and CO emissions when a sufficient HHO system is used at mid and higher speeds of engine without HECU and low speed conditions with HECU.

4. A control unit, which decreases electrolysis voltage and current automatically when the engine speed decreases under 1750 rpm for CI and 2500 rpm for SI (critical speeds for this experimental study), has to be designed and manufactured to eliminate the impairments of HHO enriched diesel fuel combustion at low speeds and to provide energy economy.

5. The average power increment in test engines during experiments is bigger than the electrical power consumed and fuel economy obtained with the aid of HHO system as well. This indicates that the system is efficient.

The process to design and manufacture was a little tedious, as we needed to do research on the different types of electrolysis and HHO generators. Many times we encountered people claiming that such generators are not efficient and that, in fact, they are a myth and don't work. This was kind of discouraging sometimes. But we kept working through with the intention of showing proof of their effectiveness. We were very pleased when we acquired the results showing an improvement in gas mileage. As engineers, we felt accomplished to know that such device can help alleviate some of society's biggest issues.

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