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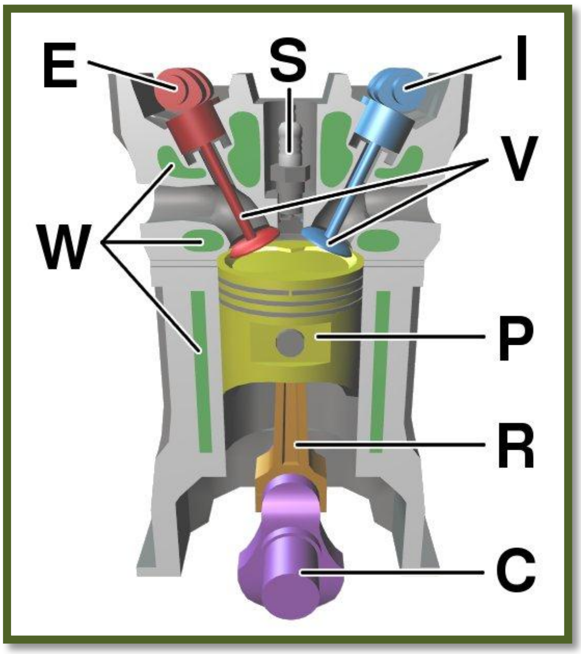
PERFORMANCE ANALYSIS OF MONO CYLINDER FOUR STROKE SPARK IGNITION ENGINE BY UTILIZING GREEN GAS (H.H.O. GAS) AS A FUEL SUPLEMENT



Abhijit A. Sur , Prashant R. Walke , Dr. M. Basavaraj

Department of Mechanical Engineering, M. Tech Heat Power Engineering Student, BIT, Ballarpur, Gondwana University, Dist.-Gadchiroli (Maharashtra state), India
Department of Mechanical Engineering, Ballarpur Institute of Technology, Ballarpur, Gondwana University, Dist. - Gadchiroli (Maharashtra state), India
Department of Mechanical Engineering, Ballarpur Institute of Technology, Ballarpur, Gondwana University, Dist. - Gadchiroli (Maharashtra state), India

ABSTRACT:

Climate change is recognized both as a threat and challenge. The impact of human activities on climate and climate system is unequivocal. Climate has significant role in economic development of any country. The use of fossil fuel is the primary source of CO_2 or greenhouse gas. Greenhouse gases trapped heat and make planet warmer. The majority of greenhouse gas emissions from transportation are CO_2 emission resulting from the combustion of petroleum base products like gasoline. In IC Engine over the 90% of fuel utilized gasoline and diesel.

The IC engine is one of the main sources to increase source of air pollution across the world. However IC engine are not perfectly efficient machine, so some of fuel is not burn inside the cylinder which produce exhaust emission, which are there major contribution to environmental pollution. Primary greenhouse gases – CO_2, CH_4, NO_X & all criteria pollutants – CO, Nitrogen Oxide, Sulfur Dioxide, Non Methane volatile organic compounds and particulate matter are major components. Noise and odor pollution is also created by IC Engine.

Now a day more researches focus on protecting the environment. There is a something new technology are being developed to serve the growing energy needs of the transportation sector without the environmental impacts observed with conventional technologies. In other words, where emissions of carbon are severally contained, hydrogen gas (HHO) or green gas powered vehicles may be the best alternative for meeting society needs. Hydrogen gas otherwise known as hydrogen or green gas produced from splitting of water into hydrogen and oxygen electrolysis process and allowing the gas used as a supplementary fuel (premixed state), to intake charge of single cylinder four stroke IC engine without any modification and need for storage tanks. Because of its clean burning characteristics, green gas injection (mixed) along with predefined air which shows very advantageous and alternative results of both performance and emission point of view.

KEYWORDS:
Electrolysis; HHO GAS (hydrogen Enriched gas); Fuel Efficiency; Fuel Consumption; Internal combustion engine (IC engine);Gasoline Engine(Petrol engine);Green gas or Hydrogen gas.

1. INTRODUCTION:

Our Earth is warming. Earth's average temperature has risen by 1.4 ^{0}F over the past century, and is projected to risen by 1.4 ^{0}F over the past century, and is projected to raise another 2 to 11.5 ^{0}F over the next hundred years. Small change in average temperature of the planet can translate to large and potentially dangerous shifts in climate and weather. The evidence is clear rising global temperature have been accompanied by change in weather and climate. Gases that trap heat in the atmosphere are called greenhouse gases (GHG) which make the planet warmer. Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities.

The largest sources of GHG emission from human activities in the world is from burning fossil fuel for electricity production, transportations, Industry, commercial and agriculture. Carbon Dioxide Emission, By Sources US-E.P.A as shown in below figure.

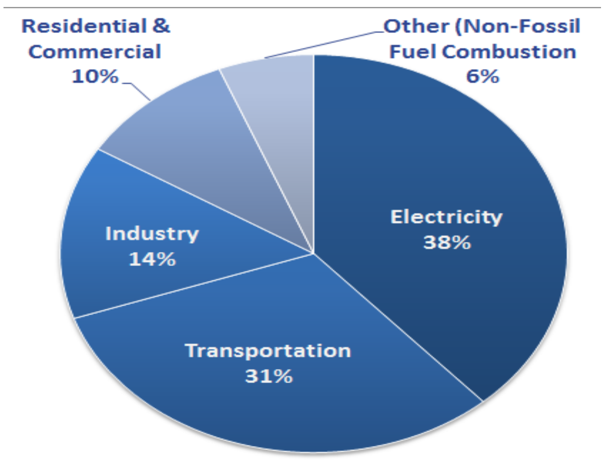


Figure1.1 all emission estimates from the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011.

The Electricity sector involves the generation, transmission and distribution of electricity. Carbon dioxides (CO_2) makes up the vast majority of GHG from the sector, but smaller amounts of methane (CH_4) nitrous oxide (N_2O) are also emitted. These gases are release during the combustion of fossil fuel, such as coal, oil, and natural gas to produce electricity.

The Transportation sector includes the movement of people and goods by cars, trucks, train, ships, airplanes, and other vehicles. The majority of GHG emissions from transportation are CO_2 emission resulting from the combustion of petroleum-based product, like gasoline, in internal combustion engine (I.C. engine). The largest sources of transportation –related GHG emission include passenger cars and light –duty trucks, including sport utility vehicles, pickup trucks, and mini-vans. These sources account for over half of emission from the sector.

Vehicle with IC Engine provide transportation worldwide. The IC engine is one of the main sources to increase source of air pollution across the world. However IC engine are not perfectly efficient machine, so some of fuel is not burn inside the cylinder which produces exhaust emissions, which are there major contribution to environmental pollutions. Primary greenhouse gases – CO_2, CH_4, NO_X & all criteria pollutants– CO, Nitrogen Oxide, Sulfur Dioxide, Non Methane volatile organic compounds and particulate matter are major components. Noise and odor pollution is also created by I.C. Engine. The figure shows global warming potential of greenhouse gases. Relatively small amount of methane (CH_4) and nitrous oxide (N_2O) are emitted during fuel combustion. In addition, a small amount hydro-fluorocarbon (HFC) emission are includes in transportation sector. These emissions result from the use of mobile air conditioner and refrigerated transports. Global Warming Potential (GWP) of the Green House Gas (GHGs) as shown in figure below.

Industrial Designation or Common Name	Chemical Formula	Lifetime (years)	Radiative Efficiency (W m–2 ppb–1)	Global Warming Potential for Given Time Horizon (100 yr)
Carbon Dioxide	CO_2	UP TO 100	$1.4*10^{-5}$	1
Methane	CH_4	12	$3.7*10^{-4}$	21
Nitrous Oxide	N_2O	14	$3.30*10^{-3}$	310

Table 1.1: Global Warming Potential (GWP) of the Green House Gas (GHGs).

In transportation sector, the most effective way to reduced carbon dioxide (CO_2) or others emission is to reduce fossil fuel consumption and utilized most effective alternative or supplementary fuels for efficient performance of I.C. engines. There are a variety of opportunities to reduce GHG or other emission associated with I.C. engine by using fuels that emits less CO_2 than fuels currently being used. Alternatively sources can include hydrogen (gas or liquid); bio-fuels; electricity from renewal sources, such as wind and solar; or fossil fuel that are less CO_2 intensive than the fuels that they replace. The modern petrol has an average efficiency about 25% to 30%. In other words, 70% to 75% of the energy stored in that expensive fuel wastes as heat, pollution (unburned fuel) and vibration. That's only 25% of energy moves the vehicle (*internet source*, 10.02.2014).There is something of great importance to the world that is being suppressed and hidden from us: That abundant, clean energy can and is being derived from water. Seawater, well water, taps water; good old H2O.hydrogen production by using hydrolysis of water is the best choice.

The hydrogen booster is utilized produces hydrogen and oxygen gas (HHO) using hydrolysis process and water droplets from the bubbler tube, these gases are then injected into intake system of the engine. The hydrogen booster is provided with electrical power from the dynamo of the engine. The input power is 12 V DC, 2.5A. It is found that the fuel consumption decreases.

Gasoline is a hydrocarbon. It needs oxygen in order to burn with a flame. It is the air that provides the oxygen; about 20% by volume. Poorer air/fuel distribution affects emissions, efficiency, and power, in that order. Increased airflow is needed to burn more fuel, which in turn releases more energy and produces more power. The gas is supplied to the engine to help the petrol burn more efficiently, while producing its own combustion. This work presents an investigation to the effect of that added combustion of the hydrogen gas gives more power and ultimately requires less consumptions petrol or gasoline to run engine that resulting in better efficiency.

This paper aspires to find out the fuel that emits minimum pollution when used in the same automobile without any modifications, thereby finding a cleaner; environment friendlier fuel. This paper investigates on green transportation across the countries, where usage of vehicles is increasing day-to- day.

2. About Green Gas or HHO Gas:

Hydrogen is the most abundant element in our universe. In addition to being a component of all living things, hydrogen and oxygen together make up water, which covers 70 percent of the earth. In its distilled form, hydrogen is a gas at normal temperatures and pressures; it is the lightest gas (even lighter than helium), with only 7 percent of the density of air. There is virtually no "free" hydrogen on earth—all of it is combined with other elements (mostly oxygen or carbon) in other substances. Every molecule of water contains two hydrogen atoms and one oxygen atom. Hydrocarbon fuels such as coal, gasoline, diesel, and natural gas also contain hydrogen. In the case of gasoline and diesel fuel, there are approximately two hydrogen atoms for every carbon atom, while natural gas contains four hydrogen atoms for every carbon atom. To be used as a fuel, hydrogen is typically separated from either water (via electrolysis) or from a hydrocarbon Fuel (via reforming).

3. METHODOLOGY:

a) Collection of HHO gas:-

Hydrogen gas is a manufactured gas used in numerous ways. Hydrogen does not exist on earth in a free state and must be manufactured from some other material that includes hydrogen as one of its components. An electrical power source is connected to two electrodes, or two plates (typically made from some inert metal such as platinum, stainless steel or iridium) which are placed in the water. Hydrogen will appear at the cathode (the negatively charged electrode, where electrons enter the water), and oxygen will appear at the anode (the positively charged electrode). Assuming ideal faradic efficiency, the amount of hydrogen generated is twice the number of moles of oxygen, and both are proportional to the total electrical charge conducted by the solution. However, in many cells competing side reactions dominate, resulting in different products and less than ideal faradic efficiency. Flow Chart for preparation HHO gas from electrolysis as shown in below figure.

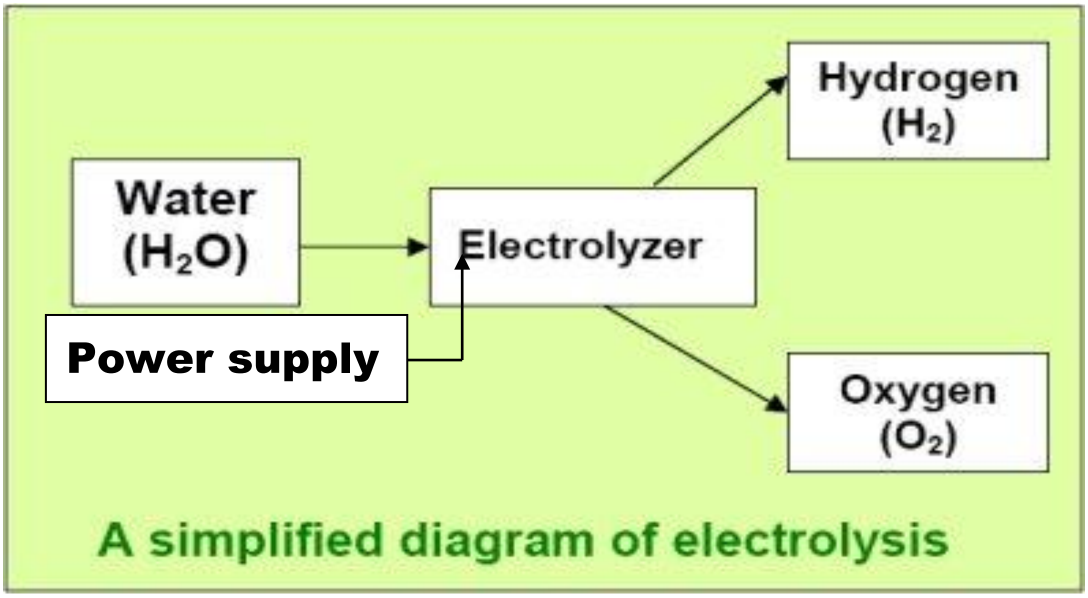


Fig 3.1: Flow Chart for preparation HHO gas from electrolysis.

b) Electrolysis process:-

Electrolysis of water is the decomposition of water (H_2O) into oxygen (O_2) and hydrogen gas (H_2) due to an electric current being passed through the water. An electrical power source is connected to two electrodes, or two plates (typically made from some inert metal such as stainless steel.) which are placed in the distilled water. Hydrogen will appear at the cathode (the negatively charged electrode, where electrons enter the water), and oxygen will appear at the anode (the positively charged electrode).

Assuming ideal faradic efficiency, the amount of hydrogen generated is twice the number of moles of oxygen, and both are proportional to the total electrical charge conducted by the solution. However, in many cells competing side reactions dominate, resulting in different products and less than ideal faradic efficiency. Electrolysis of distilled water requires excess energy in the form of over potential to overcome various activation barriers. Without the excess energy the electrolysis of distilled water occurs very slowly or not at all. This is in part due to the limited self-ionization of water. Distilled water has an electrical conductivity about one millionth that of seawater. Many electrolytic cells may also lack the requisite electro catalysts. The efficiency of electrolysis is increased through the addition of an electrolyte (such as a salt, an acid or a base) and the use of electro catalysts.

c) Electrolyzers: -

An apparatus in which electrolysis is carried out, consisting of one or many electrolytic cells. An electrolyzer is a vessel (or system of vessels) filled with an electrolyte solution, in which electrodes a cathode and anode have been placed; the cathode is connected to the negative pole of the direct-current (D.C.) source and the anode is connected to the positive pole.

An electrolyzer is a piece of electrochemical apparatus (something that uses electricity and chemistry at the same time) designed to perform electrolysis process which splitting a solution into the atoms from which it's made by passing electricity through it.

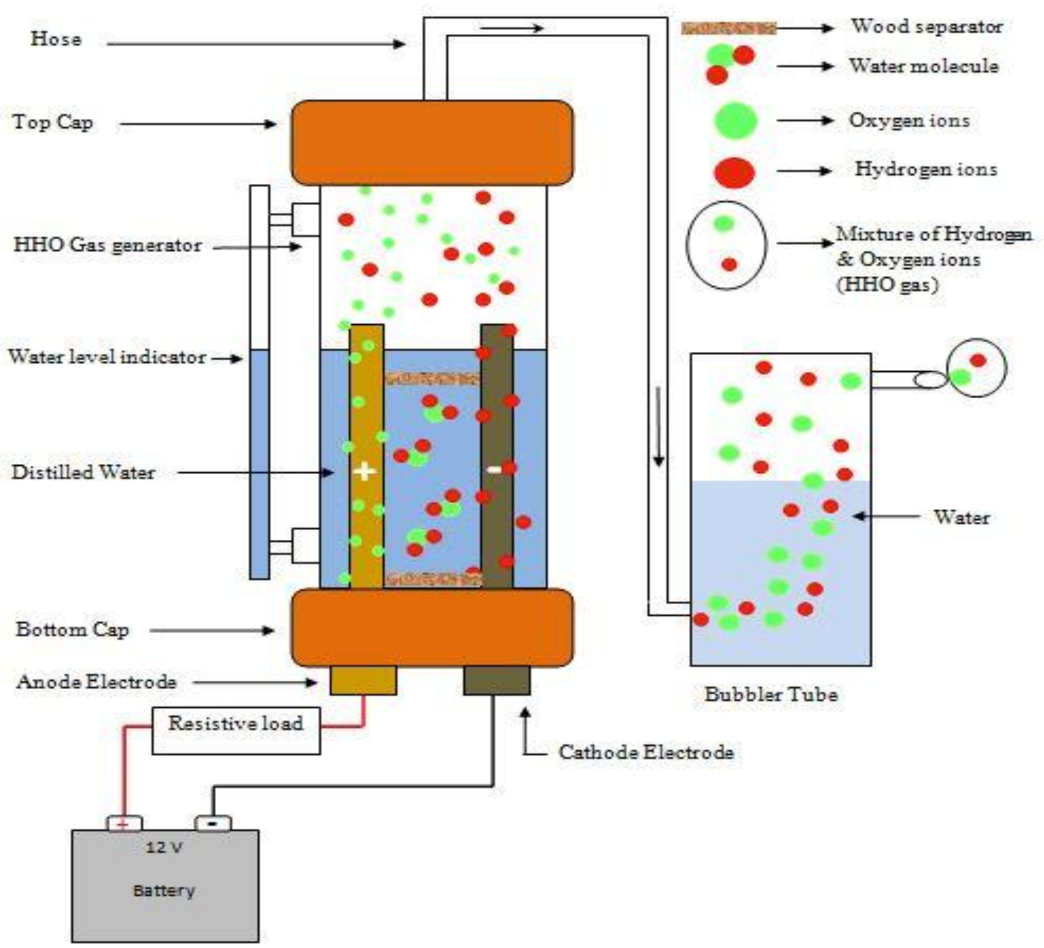


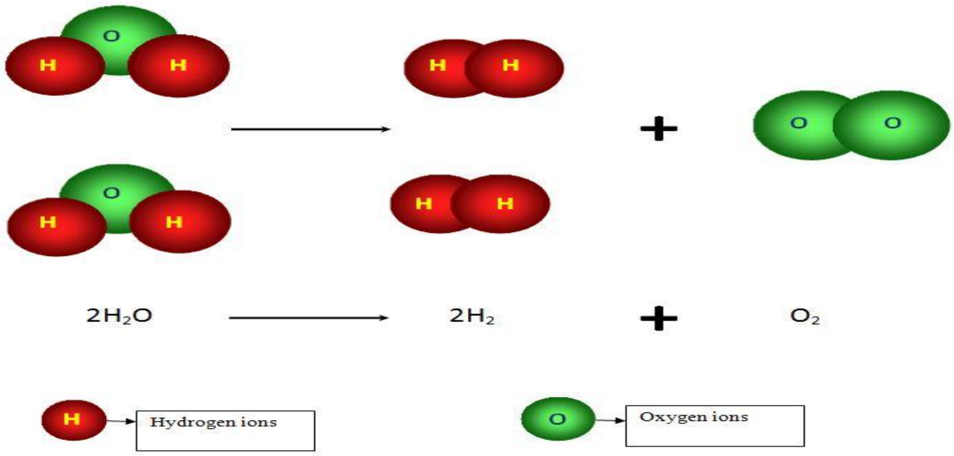
Fig 3.2: Schematic diagram of electrolysis process.

d) Working of electrolyzer or HHO generator:-

A 12 volt battery is connected the positive terminal (sometimes called the anode) to the negative terminal (or cathode) through an electrolyte. In a simple laboratory experiment, the electrolyte is used as distilled water. In a real electrolyzer, performance is improved considerably by using a potassium hydro-oxide (KOH) as the catalyst, a substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change. Electrolyzers for efficiently splitting water into high purity hydrogen and oxygen have been in industrial production for decades. A solution of potassium hydroxide (KOH) in water is used because it has low resistivity and thus lowers power loss.

The addition of electrons at the negative electrode (also called the cathode) produces hydrogen gas (H_2) and hydroxyl ions (OH-), which remain in the solution. At the positive electrode (also called the anode), electrons are removed from OH- ions, producing water (H_2O) and oxygen (O_2).When the power is switched on, water (H_2O shown here as two red blobs joined to one green one) splits into positively charged hydrogen ions (hydrogen atoms missing electrons, shown in red) and negatively charged oxygen ions (oxygen atoms with extra electrons, shown in green).The positive hydrogen ions are attracted to the negative terminal and recombine in pairs to form hydrogen gas (H_2) which is shown by red hydrogen ions. Likewise, the negative oxygen ions are drawn to the positive terminal and recombine in pairs there to form oxygen gas (O_2) which is shown by green oxygen ions.

The reactions in the module are:
Cathode: 4 H2O (l) + 4 e- → 2 H2 (g) + 4 OH⁻ (aq)
Anode: 4 OH⁻ (aq) - 4e- → O2 (g) + 2 H2O (l)
Net: 2 H2O (l) → 2 H2 (g) + O2 (g)



. Fig 3.3: Reaction scheme of Electrolysis Process

e) Electrolyzer material:-

The material used in electrolyzer is polyvinyl chloride also called as PVC. It can be made softer and more flexible by the addition of plasticizers. This unique material is glueable and weldable ,the most attractive properties like excellent resistance (no attack) to Dilute and Concentrated Acids, Alcohols, Bases, Aliphatic Hydrocarbons and Mineral Oils, PVC has high hardness and mechanical properties, the mechanical properties of PVC (rigid PVC) are very good, the elastic modulus can reach to 1500-3,000 MPa. The soft PVC (Flexible PVC) elastic is 1.5-15 MPa.
PVC is a polymer with good insulation properties but because of its higher polar nature the electrical insulating property is inferior. When the temperature reaches 140 °C PVC starts to decompose. Its melting temperature is 158 °C. Properties of electrolyzer material which is used as poly vinyl chloride as shown in below table.

Sr. no.	Properties	value
1.	Maximum Temperature	70°C (158°F)
2.	Minimum Temperature	-25°C (13°F)

3.	Melting Point	$80^{o}C$ ($176^{o}F$)
4.	Tensile Strength	148.14 bar (6500psi)

Table 3.1: Properties of electrolyzer material

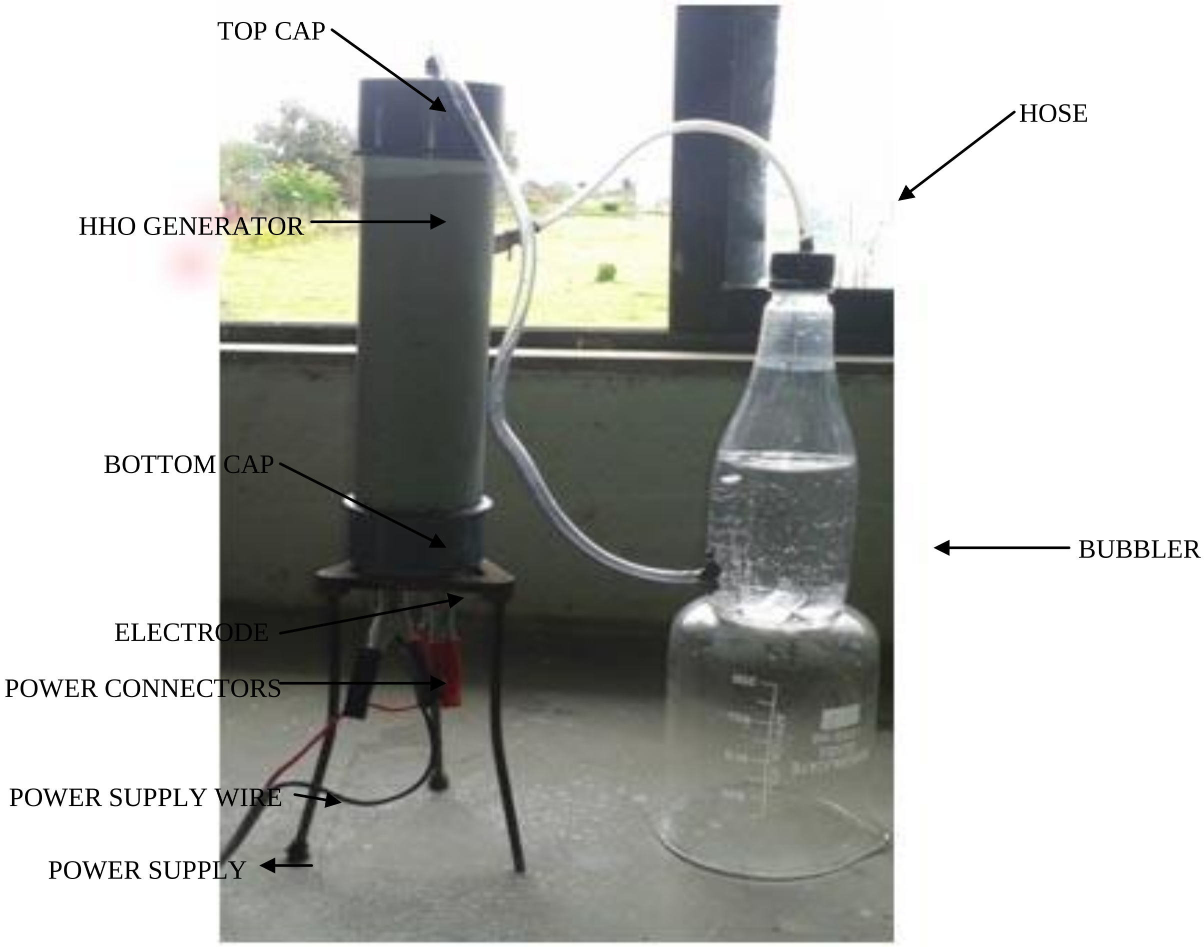


Fig 3.4: Actual lab made diagram of HHO generator

4) PROPERTIES OF GREEN GAS:

Hydrogen is the most abundant element in our universe. In addition to being a component of all living things hydrogen and oxygen together make up water, which covers 70 percent of the earth. In its distilled form, a hydrogen molecule is composed of two hydrogen atoms (H2) and is a gas at normal temperatures and pressures.

It is the lightest gas (even lighter than helium) with only 7 percent of the density of air. Hydrogen gas is colorless, odorless, tasteless, and noncorrosive, and it is nontoxic to humans. It has the second widest flammability range in air of any gas, but leaking hydrogen rises and diffuses to a nonflammable mixture quickly. Hydrogen ignites very easily and burns hot, but tends to burn out quickly. A hydrogen flame burns very cleanly, producing virtually no soot, which means that it is also virtually invisible. Hydrogen is not toxic to humans or animals. However, if leaking into an enclosed space, hydrogen gas can displace oxygen in the air and would pose an asphyxiation hazard in high enough concentrations. The risk of asphyxiation from hydrogen leaking into an open area is virtually non-existent because hydrogen is so buoyant that it will rise and diffuse to very low concentrations quickly. Properties of petrol and hydrogen as shown in below figure.

Sr. no.	Properties	Unleaded Petrol	Hydrogen
1	Auto ignition temperature (K)	533-733	858
2	Minimum ignition energy (mJ)	0.24	0.02
3	Flammability limits (volume % in air)	1.4-7.6	4-75
4	Stoichiometric air-fuel ratio on mass basis	14.6	34.3
5	Limits of flammability (equivalence ratio)	0.7-3.8	0.1-7.1
6	Density at 16 _C and 1.01 bar (kg/m3)	721-785	0.0838
7	Net heating value (MJ/kg)	43.9	119.93
8	Flame velocity (cm/s)	37-43	265-325
9	Quenching gap in NTP air (cm)	0.2	0.064
10	Diffusivity in air (cm2/s)	0.08	0.63
11	Research octane number	92-98	130
12	Motor octane number	80-90	-
13	Molecular weight	44.3g/mole	2.0158
14	Thermal conductivity	-	0.18 $W.m^{-1}.k^{-1}$
15	Colour	yellowish brown transparent colour	colorless

Table 4.1: Properties of petrol and hydrogen

5) EXPERMENTATION AND TEST SETUP:

a) Experimental set up:

The schematic diagram of experimental set up as shown in figure7.2.3. The engine set up shown is single cylinder air cooled petrol engine. The engine has rated output 5.4kw at speed 8000rpm with compression ratio 8.8:1, spark ignition engine. The detailed specification of engine is given in table no 4. Performance test are carried out on spark ignition engine using petrol as fuel with hydrogen gas as a supplement.

b) Engine technical specifications:

Engine speed	1500 rpm
Power	7.37 HP (5.4kw)
Bore	50 mm
Stroke	48.5 mm
No. of cylinder	1
Displacement	97.50 c.cm

Fuel system	Carburetor
Fuel capacity	11.00 liters (2.91 gallons)
Reserve fuel capacity	1.00 liters (0.26 gallons)
Gearbox	4-speed
Clutch	Multi-plate wet
Top speed (Kmph.)	85
Year	2006

Table no. 5.1 Engine technical specifications.

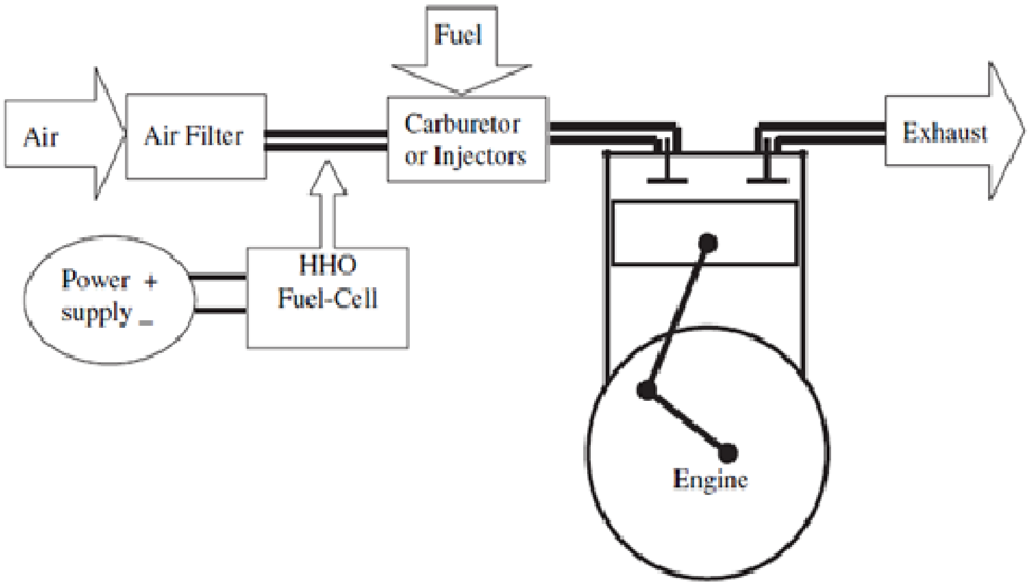


Figure5.1 Schematic illustration of the designed HHO installed on the engine.

c) Performance Parameters:

We had carried out the testing of various mixtures of HHO gas for the study of their behavior on working condition of four stroke single cylinder petrol engine. This testing enables us to determine various parameters which determine the fuel performance in the engine, which are listed below:

Sr.no.	Tests	Instruments Required
1	On Road Distance Test	Engine, Petrol, HHO Generator, Burette tube, Hoses, Bubbler Tube, Odometer, Battery etc.
2	Gear Tests	Engine, Petrol, HHO Generator, Burette tube, Tachometer, Stop watch , Battery, Bubbler Tube etc.
4	Fuel Consumption Test	Engine, Petrol, HHO Generator, Burette tube, Battery, Tachometer, Bubbler Tube, Stop watch etc.
3	Emission Test	Engine, HHO Generator, Petrol, Tachometer, Exhaust gas analyzer, Battery, Hoses, Bubbler Tube etc.

Table No. 5.2: Performance Parameters Single cylinder four stroke engine

d) Procedure:-

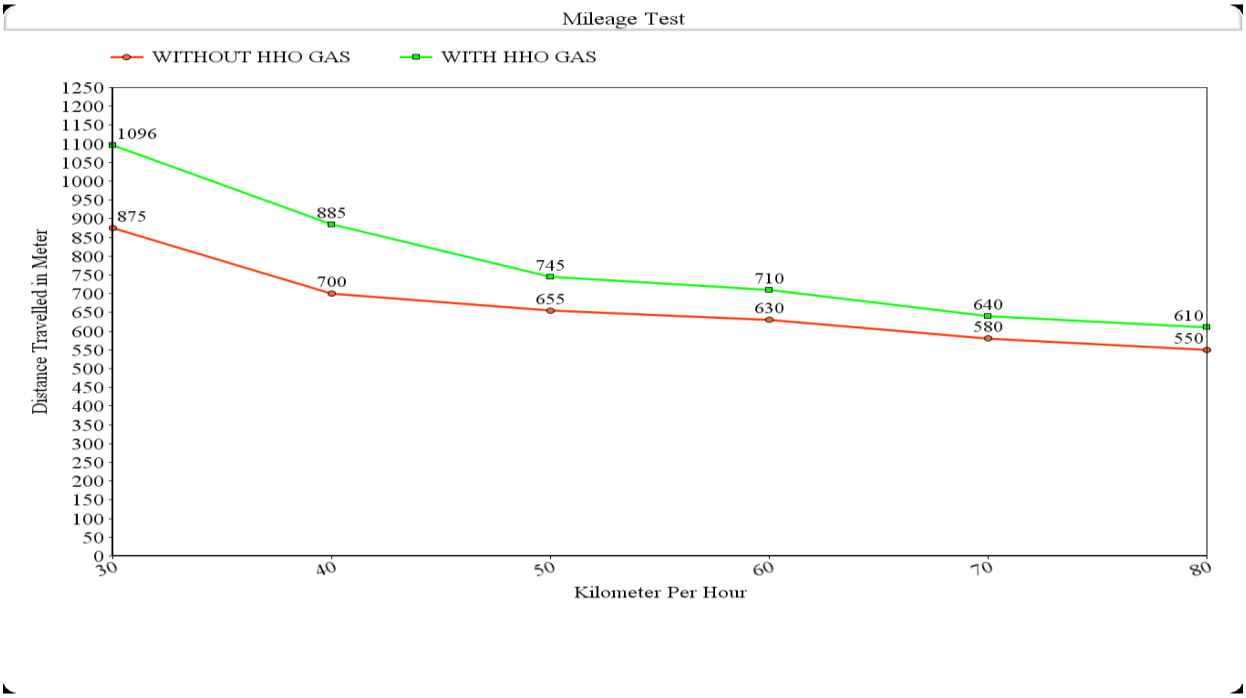
For on road distance testing –

- First collect all required instruments for testing.
- Then the fuel tank was filled with conventional petrol with safety precautions.
- Engine was started and run at no load condition for 3-4 minutes.
- Then the burette connected instead of fuel tank and was filled up to 5ml.
- Then take reading first only for pure petrol with 5ml and note down it.
- After note down of first reading, performed second test with using HHO gas as a fuel.
- After taking both readings compared both reading with plotting of graph and charts.

Fig5.2: Single cylinder four stroke spark ignition engine setup.

6) ENGINE PERFORMANCE AND EMISSION PARAMETERS FOR HHO GAS AS A FUEL SUPPLEMENTS.

1) On Road Distance test: Travelled distance Vs different speeds.
At full load- 120kg (constant load).
Petrol -5ml. (sample).
Instruments required- shown in Table No.5.2



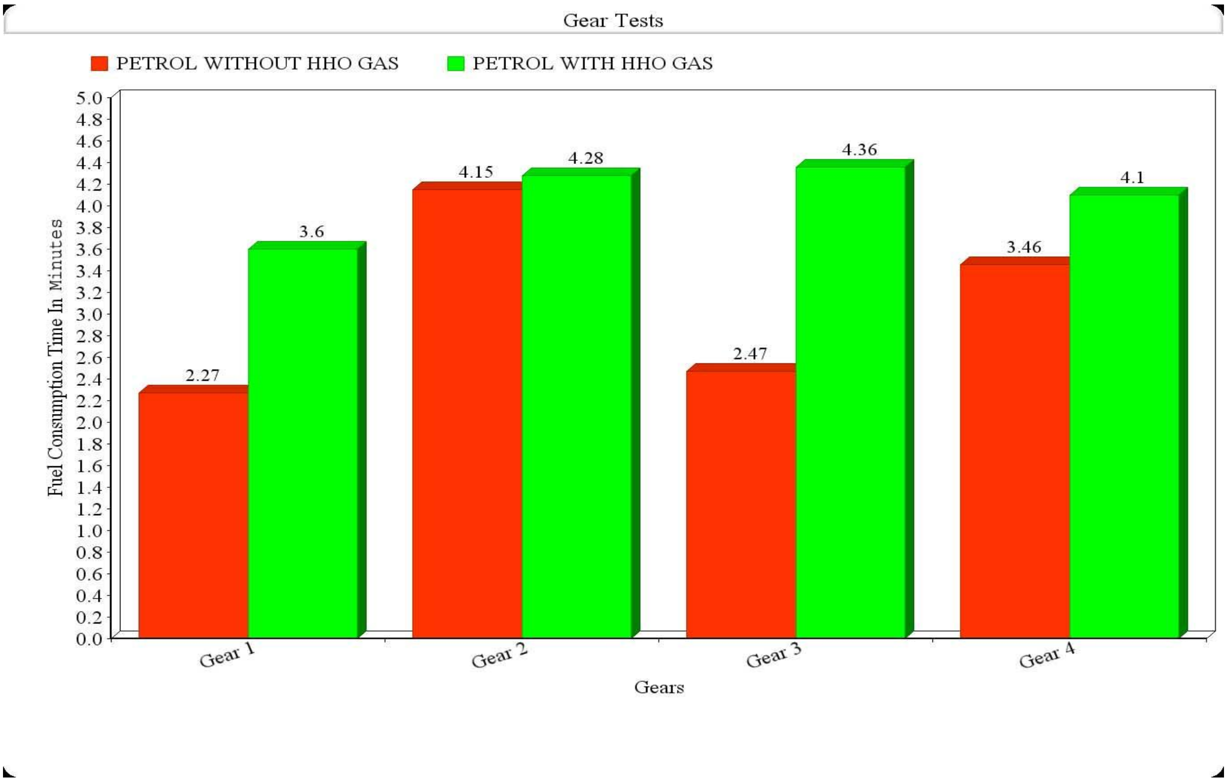
Graph 6.1.1: distance travelled at different speeds.

2. Gear test: - Fuel consumptions Vs. Different gears.

At no load conditions.

Petrol -5ml. (sample) for each gear.

Instruments required- shown in Table No.5.2



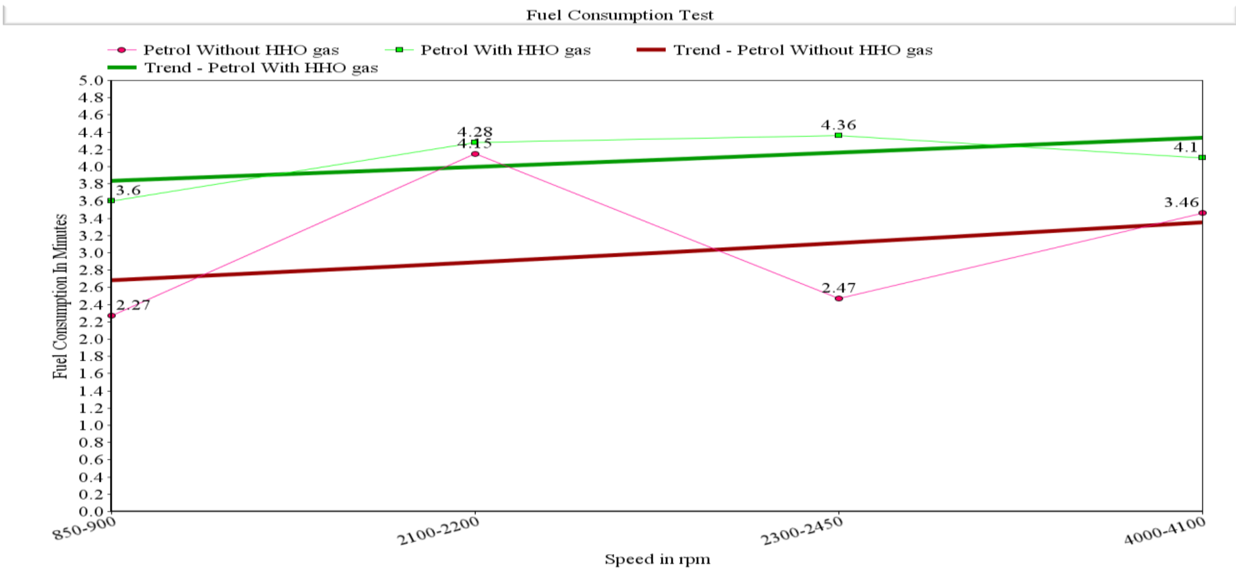
Graph 6.2.1: Variation of fuel consumptions at different gears.

3. Fuel Consumption test: - Fuel consumptions Vs. Speeds.

At no load conditions.

Petrol -5ml. (sample) for each gear.

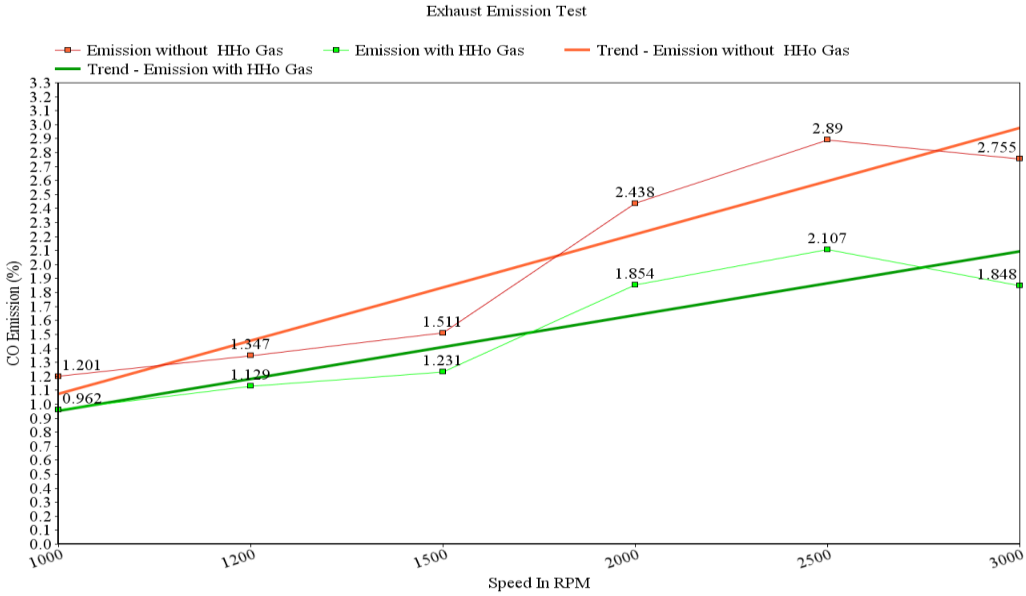
Instruments required- shown in Table No.5.2



Graph 6.3.1: Variation of fuel consumptions at different speeds.

4. **Emission test: -** CO emission Vs Speeds.

At no load conditions.
Petrol -5ml. (sample).
Instruments required- shown in Table No.5.2



Graph 6.4.1: Variation of CO emissions at different speeds (rpm).

6) CONCLUSION

Using HHO gas as a fuel causes an improvement in engine performance and exhaust emissions. Hydrogen gas has become increasingly important due to the environmental consequences of fossil fuel based petrol engines and the decreasing petroleum resource. The main challenges in the production of hydrogen gas are its cost and availability of different methods.

In this work, a HHO gas generator was designed, manufactured and tested. The generated HHO gas was introduced to the air stream just before entering the carburetor of a **Hero Honda Splendor engine.**

The following conclusions can be drawn:

1. The use of HHO gas in gasoline engines enhances combustion efficiency, consequently reducing fuel consumption and thereby decreasing pollution.
2. The volume of water needed in the cell is about one and half times the engine capacity.
3. The HHO gas generator unit which can be used is simple, easily constructed, and easily integrated with existing engines at low cost. (approximately 1500 INR for each generator).

These investigation leads to conclude that HHO gas which are made from hydrolysis (electrolysis) with gasoline fuel can be use as a supplementary fuel and has low emission rates. In exhaust parameter CO is decreases with increase in mixture proportions.

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