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Better Performance of Vehicles Using HHO Gas

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Abstract Facing with the ever increasing cost of conventional fossil fuels, worldwide researches are working overtime to cost effectively improve internal combustion engine (ICE) fuel economy and emission characteristics. In recent years, many researchers have focused on the study of alternative fuels which benefit enhancing the engine economic and emissions characteristics. The main pollutants from the conventional hydrocarbon fuels are unburned/partially burned hydrocarbon (UBHC), CO, oxides of nitrogen (NOx), smoke and particulate matter. It is very important to reduce exhaust emissions and to improve thermal efficiency.In this project, hydroxy gas (HHO) was produced by the electrolysis process of an electrolyte (KOH(aq)) with stainless steel electrodes in a leak proof plexiglass reactor (hydrogen generator). Hydroxy gas was used as a supplementary fuel in a single cylinder, spark ignition (SI) engine without any modification and without need for storage tanks. Its effects on exhaust emissions, engine performance characteristics and specific fuel consumption are investigated.

Keywords: *hydrogen, hydroxy gas, electrolysis, performance, emissions*

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1. Introduction

Hydrogen lobbyists promote hydrogen as potential fuel for motive power (including cars and boats), the energy needs of buildings and portable electronics. Free hydrogen does not occur naturally, and thus it must be generated by electrolysis of water or another method. Hydrogen is therefore an energy carrier (like electricity), not a primary energy source (like coal). The utility of a hydrogen economy depends on issues of energy sourcing, including fossil fuel use, climate change, and sustainable energy generation.

1.1. Principle

An electrical power source is connected to two electrodes, or two plates (typically made from some inert metal such as platinum or stainless steel) 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 faradaic 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 faradaic efficiency. Electrolysis of pure water requires excess energy in the form of over potential to overcome various activation barriers. Without the excess energy the electrolysis of pure water occurs very slowly or not at all. This is in part due to the limited self-ionization of water. Pure water has an electrical conductivity about one millionth that of seawater. Many electrolytic cells may also lack the requisite electrocatalysts. 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 electrocatalysts. Currently the electrolytic process is rarely used in industrial applications since hydrogen can currently be produced more affordably from fossil fuels

1.2. 316L Stainless Steel Plates for HHO Kit as Terminals

316L plates are a bit more expensive but are vastly superior to 304 Grade plates for use in HHO generators. We only use 316L stainless steel plates in our personal HHO Dry Cells and hho generators so why would we recommend any thing less to others. Grade 316 is the standard molybdenum-bearing grade, second in importance is 304 amongst the stainless steels. The molybdenum gives 316 better overall corrosion resistant properties than Grade 304, particularly higher resistance to pitting and crevice corrosion in chloride environments. Grade 316L is the low carbon version of 316 and is immune from sensitization (grain boundary carbide precipitation).

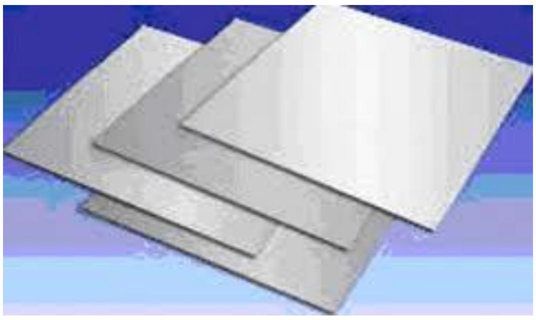


Figure 1. Stainless steel electrodes

1.3. Electrolyte

The Electrolyte is important because it is what Hydrogen generators use to maintain the right voltage across the plates and to carry electrical current from plate to plate. They make the water a better conductor because pure water is an insulator. It will not conduct any current. Pure water is rare. Most water contains minerals which are conductors. The more minerals, the better it will conduct. But when it comes to our hydrogen generators, we need to minimize or eliminate impurities in the water that pollute electrode surfaces and stop the chemical process of electrolysis.

Figure 2. KOH Electrolyte

1.4. The Best Electrolyte for HHO is Potassium Hydroxide - KOH

Potassium Hydroxide is the best electrolyte for a Hydrogen Generator. It is excellent also for Making Liquid Soap. Potassium hydroxide is a corrosive materials used in making soap, some food products, in fuel cells, and in making bio diesel fuel.

- Produces more HHO than other type of electrolyte;
- Electrodes stay clean - non sediment electrolyte;
- Lowers the freezing point of water.

I prefer to look at HHO as a "Combustion Catalyst", NOT a fuel replacement technology, in this stage of advancement. HHO burns way too fast by itself and actually works better if it is "slowed down" by the gasoline, diesel, Compressed Natural Gas (CNG), Liquefied Petroleum Gas (CNG), or biodiesel fuel. That makes it perfect in a gas saving application, where it can burn the fossil fuels faster, extracting more energy out of it inside the engine, instead of having to filter or convert it.

2. Design, Experiment, Result & Discussion

In this experimental study, hydroxy gas (HHO) which is produced by the electrolysis process of an electrolytes KOH(aq) with reactor (electrode) designs in a leak-proof plexiglass reactor (hydrogen generator) is used as a supplementary fuel in a single cylinder, four stroke, SI engine without any modification. HHO was firstly sent to a water safety system to prevent backfire using a 1/3 water-filled pot before being sent to the intake manifold. Sensors are located on the container to observe excess growth of water temperature and gas pressure. Non-turn valve is used to prevent rising of gas pressure over 1 bar in the container. An electronic hydrogen leak detector is used for probable gas leaks. HHO is used as a sole fuel for gasoline and diesel fuel is in brown color and the form of unseparated hydrogen and oxygen generated by the electrolysis process of water by a unique electrode design. Hydrogen and oxygen do not form into O_2 and H_2 molecules. They are in their mono-atomic state (a single atom per molecule). In this state, which is an unstable state of H_2O vapor, more energy is achieved compared to hydrogen burning with oxygen. Pulverized water clashes the fuel and they unite. Water becomes the core and the fuel tends to be the water shell (due to density difference).

At a design and development stage an engineer would design an engine with certain aims in his mind. The aims may include the variables like indicated power, brake power, brake specific fuel consumption, exhaust emissions, cooling of engine, maintenance free operation e.t.c. The other task of the development engineer is to reduce the cost and improve power output and reliability of the engine. In trying to achieve these goals he has to try various design concepts. After the design the parts of the engine are manufactured for the dimensions and surface finish and may be with certain tolerances. In order verify the designed and developed engine one has to go for testing and performance evaluation of the engines.

Table 1. Basic system materials and members

Item	Quantity
Cylindrical plexiglass (170mm x400mm x1,5mm / DxL xT)	1
316 L stainless steel electrode plates (115mm x 70mm x 2mm / D x L x T)	2
Cylindrical polyamide reactor lids (170mm x 75mm / Dx L)	1
DC device (automobile battery)	1
Catalysts (KOH)	~1% by Mass

Figure 3. HHO Kit

Hydrogen (HHO) generators create a "hydroxy" gas. When this gas is added to vehicles fuel system it increases the combustion of the fossil fuel and more power is created, giving the vehicle better gas mileage, increased performance and more horsepower. Not to mention the known fact that vehicle will produce less harmful, emissions.

Internal combustion engine has an approximate energy efficiency of 25% or less, and 75% of the energy created by the air/fuel mixture in the engine is wasted in a form of gases and heat that leave your exhaust and create pollution.

By adding hydrogen gas to vehicles air/fuel mixture increase engines efficiency. That gives better gas mileage since less gas is wasted. The reason is because the added “HHO” gas is much more explosive than petrol. When mixed with other fuels it makes the fuel explode in the combustion chamber more efficiently thus increasing the combustion process in the engine. Using hydrogen generators will increase vehicle mileage, horsepower by the increased combustion of fuel. In addition to saving money on fuel, this will also cut down exhaust emissions since less fuel is being wasted in the combustion process and is consumed, which benefits the environment.HHO is generated and used as a sole fuel in SI engine to benefit from peculiar features and minimize disadvantages of hydrogen.

2.1. Description

The test rig consists of four stroke petrol engine, to be tested for performance is connected to rope brake drum with spring balance (mechanical dynamometer). The arrangement is made for the following measurements of the set-up.

1. The rate of fuel consumption is measured by using the pipette reading against the known time
2. Air flow is measured by manometer connected to air box.
3. The different mechanical loading is achieved by operating the spring balance of dynamometer in steps.
4. The different mechanical energy is measured by spring balance and radius of brake drum.
5. The engine speed(rpm) is measured by electronic digital rpm counter.
6. Temperature of the different points is measured by electronic digital temperature indicator.

The whole instrumentation is mounted on a self contained unit ready for table operation.

2.2. Technical Specifications of the SI test Engine

• Configuration	One-cylinder
• Type	SI Petrol engineair cooled
• Swept Volume (cm3)	102
• Bore (mm)	50
• Stroke (mm)	52
• Compression Ratio	9:1
• Maximum Torque (Nm)	7.84 at 5500 rpm
• Maximum Brake Power (kW)	5.22 at 7000 rpm
• Transmission	Variomatic
• Clutch	Dry automatic centrifugal
• Ignition	CDI

2.3. Performance Parameters

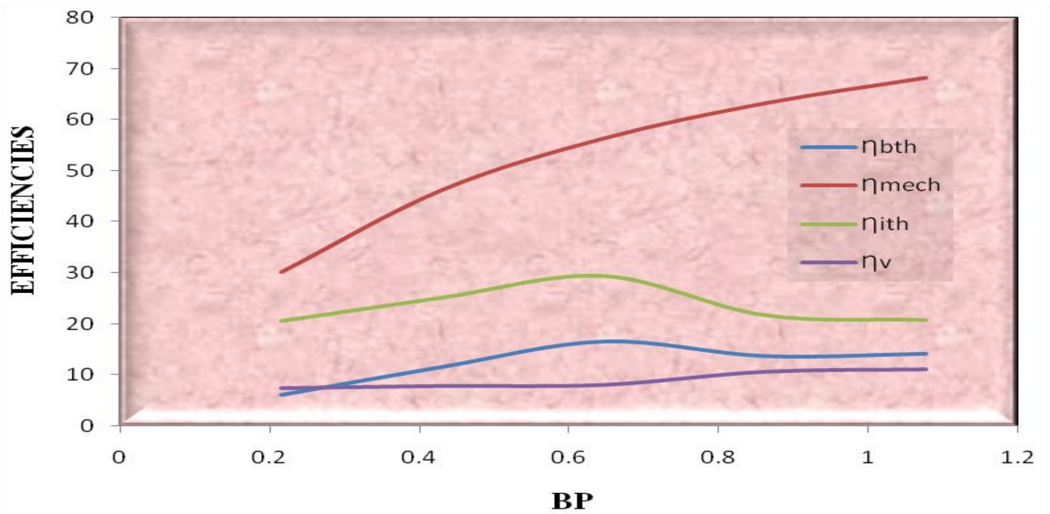
Engine performance is indication of the indication of the degree of the success of the engine performs its assigned task, i.e. the conversion of the chemical energy contained in the fuel into the useful mechanical work. The performance of the engine is evaluated on the basis of the following:

a) Specific Fuel Consumption
b) Brake Mean Effective Pressure
c) Specific Power Output.
d) Specific Weight.
e) Exhaust Smoke and Other Emissions.

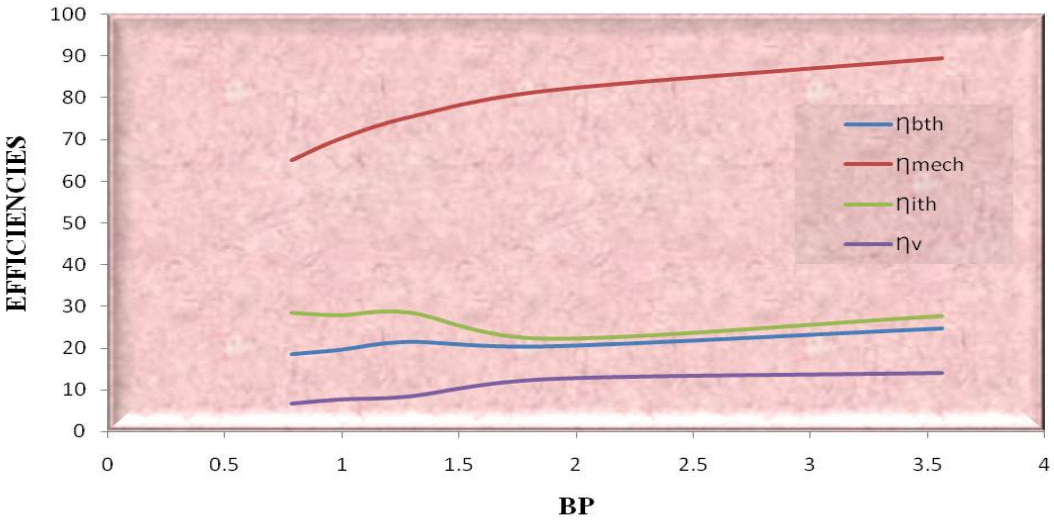
The particular application of the engine decides the relative importance of these performance parameters. For the evaluation of the performance few more parameters are chosen and the effects of the various operating conditions, design concepts and modifications on these parameters are studied. The basic performance parameters are the following:

a) Power and Mechanical Efficiency.
b) Mean Effective Pressure and Torque.
c) Specific Output.
d) Volumetric Efficiency.
e) Fuel- air Ratio.
f) Thermal Efficiency and Heat Balance.

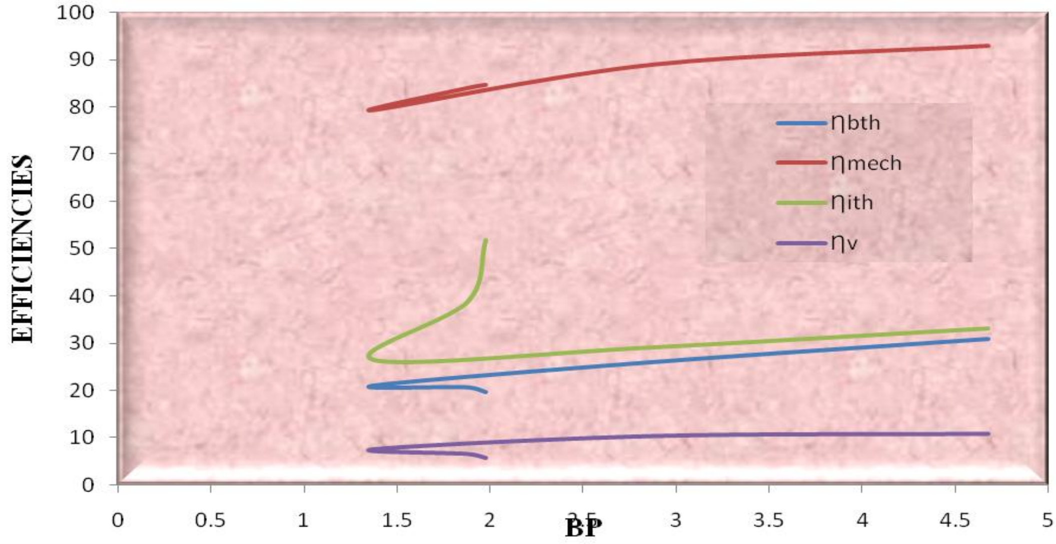
2.4. Graphs of Petrol Engine without HHO Kit



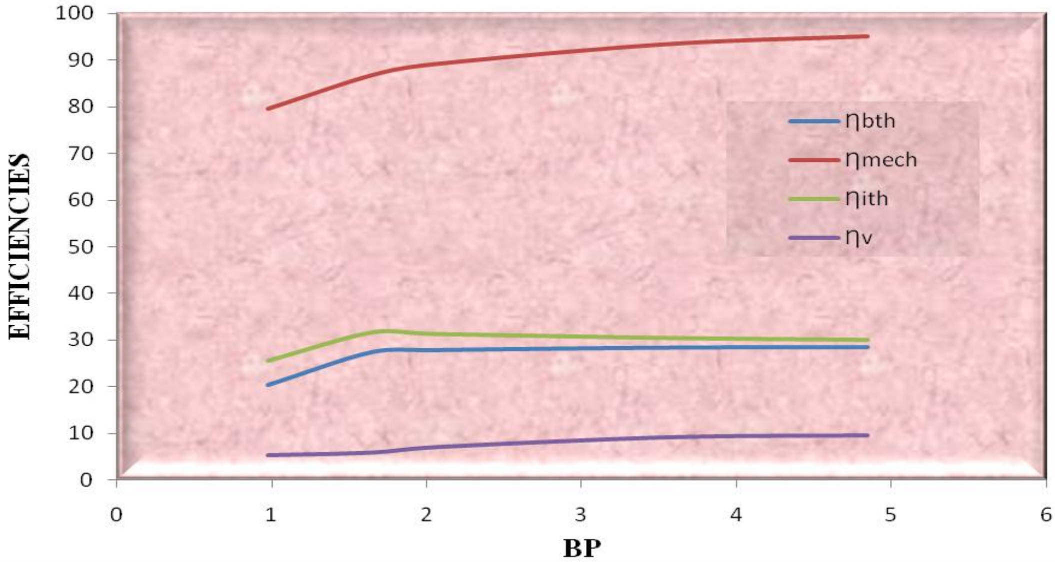
Graph 1. Variation of Brake Power (BP) with Efficiencies at 700 rpm



Graph 2. Variation of Brake Power (BP) with Efficiencies at 900 rpm

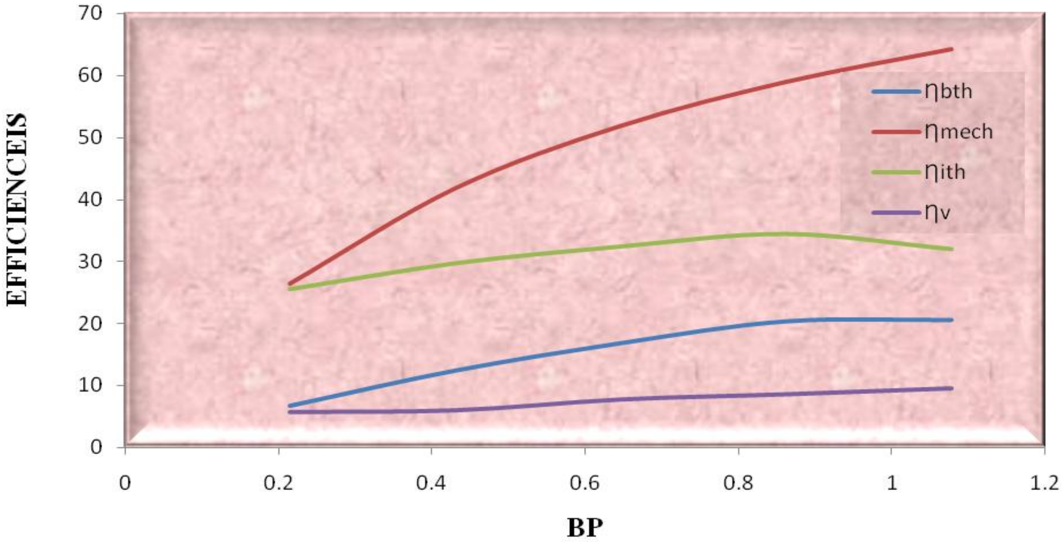


Graph 3. Variation of Brake Power (BP) with Efficiencies at 1100 rpm

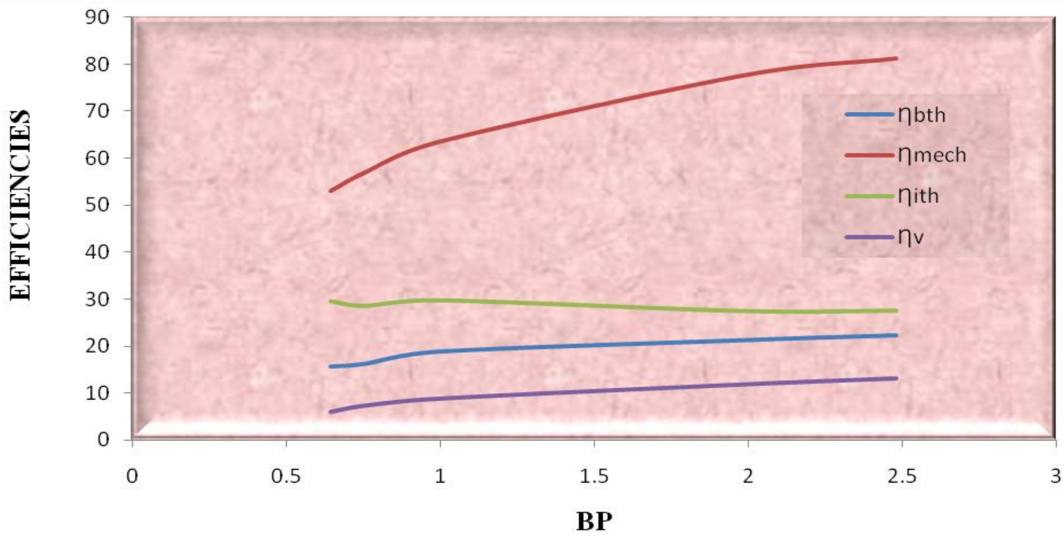


Graph 4. Variation of Brake Power (BP) with Efficiencies at 1300 rpm

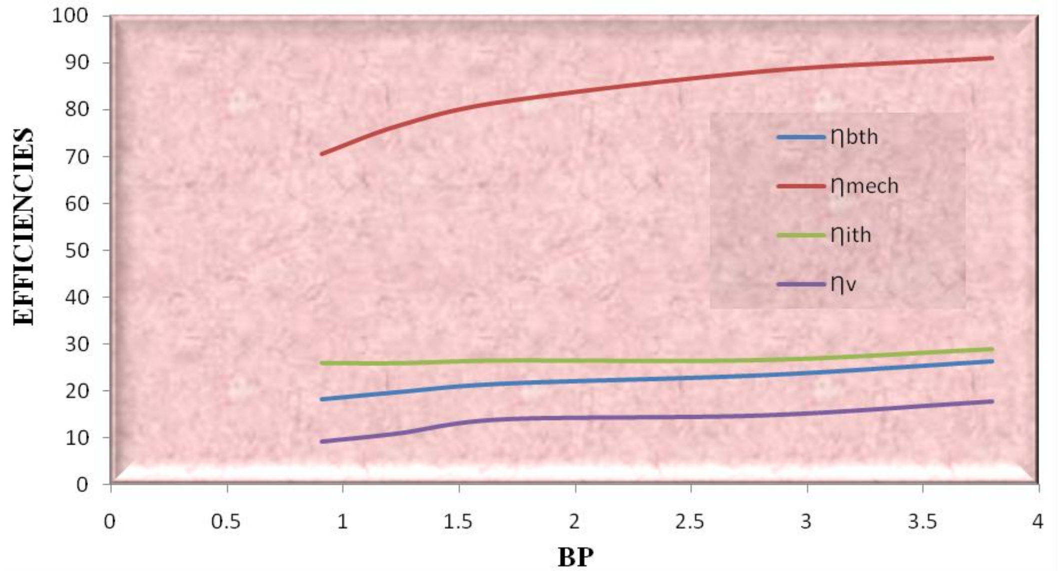
2.5. Graphs of Petrol Engine with HHO Kit



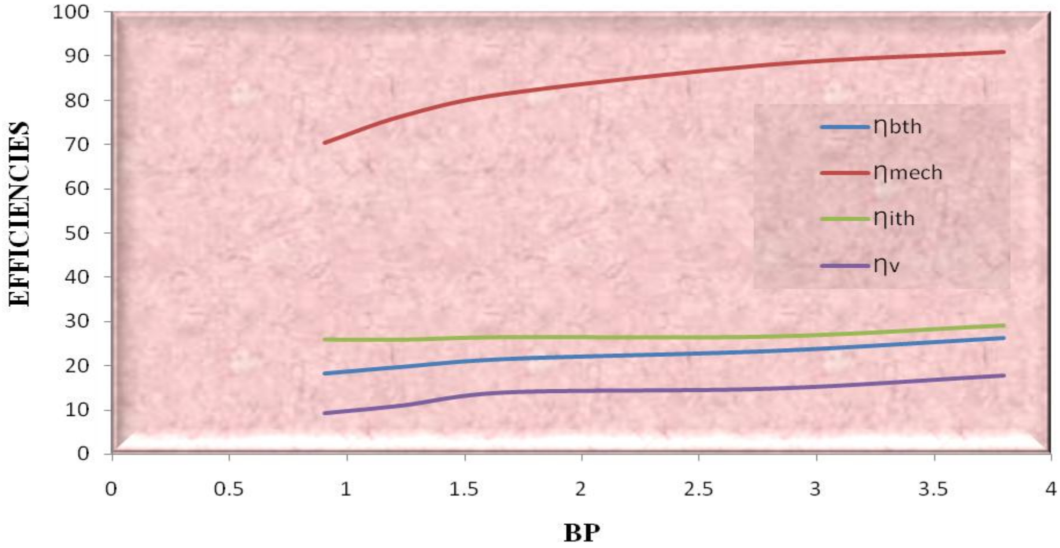
Graph 5. Variation of Brake Power (BP) with Efficiencies at 700 rpm



Graph 6. Variation of Brake Power (BP) with Efficiencies at 900 rpm



Graph 7. Variation of Brake Power (BP) with Efficiencies at 1100 rpm



Graph 8. Variation of Brake Power (BP) with Efficiencies at 1300 rpm

Table 2. HEAT BALANCE SHEET FOR PETROL ENGINE WITHOUT HHO KIT

Heat Input (per minute)	KJ	Heat expenditure (per minute)	KJ	Percent (%)
Heat supplied by the fuel	864	1.Heat Equivalent In IP	250.5126	28.99
		2.Heat Taken Away By Exhaust Gases	1.066104	0.123392
		3.Unaccounted Loses	612.4213	70.88
		4.Total	864	100

Table 3. HEAT BALANCE SHEET FOR PETROL ENGINE WITH HHO KIT

Heat Input (per minute)	KJ	Heat expenditure (per minute)	KJ	Percent (%)
Heat supplied by the fuel	1016.472	1.Heat Equivalent In IP	305.7946	30.0838
		2.Heat Taken Away By Exhaust Gases	1.166104	0.114592
		3.Unaccounted Loses	709.51659	69.8
		4.Total	1016.472	100

Table 4. EXHAUST EMISSIONS OF A SI ENGINE WITHOUT HHO KIT

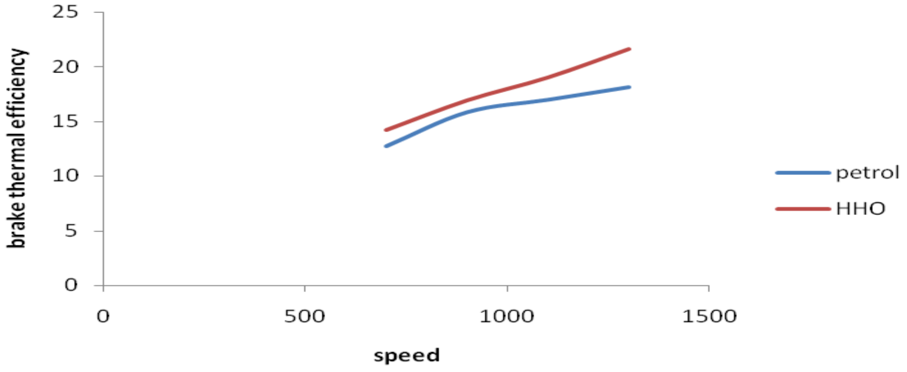
S.NO	O_2	CO	CO_2	NO_x	HC
1	12.75	0.269	5.97	0.0078	0.0012
2	11.71	0.306	5.73	0.0193	0.0033
3	7.30	0.520	5.20	0.0284	0.0048
4	6.02	0.912	4.498	0.0379	0.0066

Table 5. EXHAUST EMISSIONS OF A SI ENGINE WITH HHO KIT

S.NO	O_2	CO	CO_2	NO_x	HC
1	12.95	0.0554	5.41	0.0069	0.0013
2	12.86	0.0621	5.25	0.0106	0.0028
3	12.30	0.0764	4.91	0.0243	0.0036
4	10.84	0.7976	3.68	0.0295	0.0058

2.6. Brake Thermal Efficiency

The variations of brake thermal efficiency at different loads level with HHO addition were plotted at different rpm, with varying load from 0-10 kg. It can be observed from Fig. thermal efficiency vs load level, that regardless of any load levels, thermal efficiency increases with induction of hydroxy gas in both case of petrol. The flame speed of hydrogen is nine times faster than that of petrol fuel and mixture of gas contains oxygen, therefore, it enhances combustion more complete. This will produce high peak pressure which contributes to improve thermal efficiency. However, figure shows that, with maximum flow rate of hydroxy gas about 10L/h, thermal efficiency of petrol fuel increases from 0.33%to 2.27%.



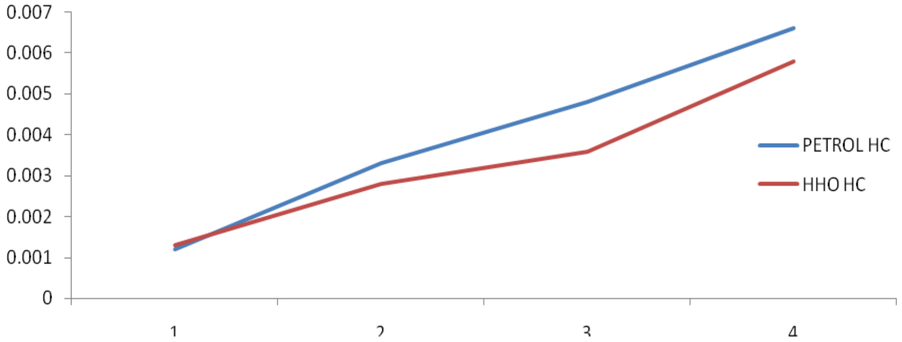
Graph 9. Variation of speed with brake thermal efficiency for petrol and HHO gas

2.7. Specific Fuel Consumption (SFC)

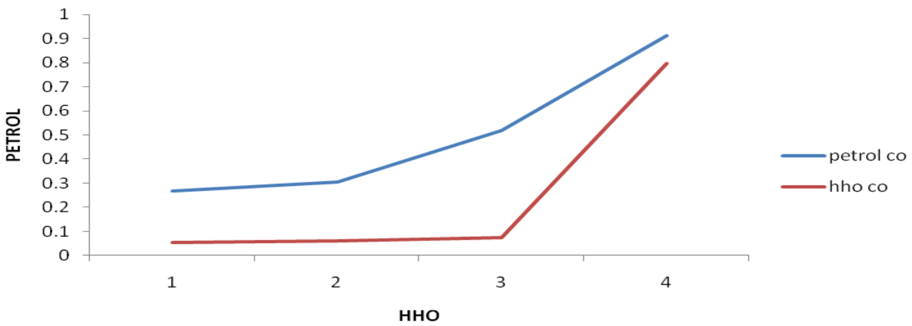
An average gain of 16.3% is achieved in SFC by using HHO system. Brake thermal efficiency is usually used to symbolize the engine economic performance. The improvement in engine brake thermal efficiency for the HHO enriched SI engine is more evidently seen at low manifold absolute pressure (MAP) conditions. 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.

2.8. 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 1.6 Liters/min (Graph 10).



Graph 10. Variation of flow rate with hydrocarbon (HC) emissions for petrol and HHO gas



Graph 11. Variation of flow rate with carbon monoxide (CO) emissions for petrol and HHO gas

2.9. 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 (Graph 11).

3. Conclusion

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 single cylinder SI engine by a HHO system and a HECU under various loads.

Electrolytes are used to diminish oxygen and hydrogen bonds. HHO is used as a supplementary fuel in a four cylinder, four stroke, 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

3.1. Benefits with HHO Gas

• **Environment Friendly Exhaust**

This is a no brainer. Since water is purely natural and completely renewable, the exhausts from a water driven car are far less hazardous as compared to those from a gas driven car. Water consists of hydrogen and oxygen and when combusted in your car engine, hydrogen along with the fuel is used to power the crankshaft while oxygen is released as exhaust. Hence, your car will release oxygen into the atmosphere which will help immensely in regenerating our environment.

• **Enhanced Engine Life**

Water has several soothing effects on various engine components. Engine components like rings, bearings and piston show higher efficiency when in contact with water. This is because, water being a solvent, takes additional heat away from these components thereby enhancing their life. Usage of water also removes the carbon deposits, which lower the combustion efficiency of the engine.

• **Noiseless Engine Operation**

Engine noise is directly proportional to engine temperature. Hence, as temperature increases, engine noise increases as well. When water is used along with the fuel, it acts as a coolant, thereby controlling the operating temperature and hence the noise level of the engine. This also leads to smoother operation of the engine and effortless gearshifts.

• **Increase in Mileage**

Due to improved engine performance and enhanced quality of combustion cycle, your vehicle will experience an improvement of 40 to 60 percent in mileage. Even if we go by a conservative estimate of 40%, then this is an annual saving of approximately two thousand dollars. In case you have more than one car, then your savings can be manifold.

References

[1] G.H. Abd-Alla. 2002. “Using Exhaust gas Recirculation in Internal Combustion Engines: a Review”, energy conversion and management, 43: 1027-1042.

[2] Sybil P. Parker, 1994. “Concise Encyclopedia of Science and Technology”, McGraw- Hill.

[3] DAS, L. M., 2002. Near-Term Introduction of Hydrogen Engines For Automotive and Agriculture Application. International Journal of Hydrogen Energy, 27:479 87.

[4] WHITE,C. M., STEEPER, R. R., and LUTZ, A. E., 2006. The Hydrogen-Fueled Internal Combustion Engine: A Technical Review. International Journal of Hydrogen Energy, 31: 1292-1305.

[5] D ANDREA, T., HENSHAW, P. F., and TING, D. S., 2004. The Addition of Hydrogen to a Gasoline-Fuelled SI Engine. International Journal of Hydrogen Energy, 29:1541-52.

[6] DULGER, Z., and OZCELIK, K. R., 2000. Fuel Economy Improvement by On- Board Electrolytic Hydrogen Production, International Journal of Hydrogen Energy, 25:895-97.

[7] CUNNINGHAM, J. E., and GOODENOUGH, R. Method and Apparatus for Enhancing Combustion in an Internal Combustion Engine through Electrolysis. United States Patent, April, 21, 1992.