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THE ELECTROLYSIS OF WATER TO GENERATE HYDROGEN (HHO) AND A STUDY OF THE EFFECT OF ADDITION OF HHO TO GASOLINE AS AN ENGINE PERFORMANCE IMPROVER

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ABSTRACT

The purpose of this work is to fabricate a simple innovative HHO generation system through the process of water electrolysis and evaluate the effect of hydroxyl gas HHO addition to petrol, used as fuel in 4-stroke engine. HHO cell is optimized for maximum HHO gas productivity per input power. The type of catalyst is varied with potassium hydroxide as the optimized system. The results showed that the maximum productivity of the cell was 68 L/h HHO gas when 6 g/L of KOH is used. The results also showed 55% in the gasoline engine thermal efficiency.

***KEYWORDS:** Electrolysis, Fuel & Thermal Efficiency*

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Original Article

INTRODUCTION

Background Information

H_2 (hydrogen gas) is being considered as an alternative fuel to enhance engine efficiency and produce less pollution. This is not feasible in a commercial point of view as it increases the manufacturing cost and impacts the vehicle market price. Mohamed El-Kassaby [1] have designed, integrated and tested a compact HHO generating device on a gasoline engine. Their results showed that fuel consumption was reduced approximately by 34%. The effect of HHO addition on SI engines was studied by Kuware [2] et al. their results reported a reduction in Specific Fuel consumption (SFC) of 20-30%.

The effect of H_2 enrichment on a diesel engine was studied by Dahake [3] et al and reported an increase in both the thermal and volumetric efficiencies. Shiva Prasad [4] et al has experimented on a single cylinder SI gasoline engine while injecting H_2 in the intake manifold in volumetric fractions (Vf) of the intake air between 5% and 25%. The results reported a continuous increase in B_{mep} and thermal efficiency.

Wang [5] et al. has conducted a number of experiments on a DI 4-cylinder gasoline engine to investigate the performance of H_2/gasoline blends. In most of the experiments, the engine was operated in a city driving condition of 1400 rpm. Results in outline the general qualities offered by H_2 without any other modifications to the engine. Notably, the spark timing of the original gasoline operation was not modified, despite the predictable fast combustion of H_2/gasoline. The results demonstrate a most profound enhancement in B_{mep} and thermal efficiency in lean conditions, and an increase in peak cylinder pressure and an advance in the corresponding crank angle (CA) with the increase in H_2%. Besides, the gasoline fuel flow was reduced with H_2 enrichment – to maintain constant global mixture equivalence and compare the engine performance with pure gasoline – so, lesser HCs content is in the fuel, which cuts the formation of CO, CO_2 and HC and promotes economic fuel consumption. Furthermore, hydrogen has a higher diffusion coefficient than that of the gasoline, and so, the gaseous H_2 can disperse thoroughly in the charge and allow for greater mixture homogeneity and combustion completeness.

Hydrogen has a higher flame speed and its gasoline blend can be combusted faster. Still, as H_2 addition widen the mixture flammability limit to leaner fuel equivalence, the reaction rate will be reduced and combustion would be prolonged in lean conditions. It was found that HHO-gasoline blends can provide a comparable performance to H_2 blends. HHO was claimed to grant a greater enhancement in thermal efficiency. HHO was reported to reduce the CA of heat release duration. The unsolved problems exist in both the automobile product and manufacturing process. The IC engine technology, as such is one of the oldest. In the IC engine, petrol or diesel fuel gets converted to mechanical power by means of controlled combustion. So, we decided to reduce the emission of the vehicles by using HHO gas as the supplementary fuel. By using this fuel thermal and mechanical efficiencies are also increased. HHO gas is available in abundant form and can be extracted from many kinds of sources, in this case by water electrolysis.

Material and Experimentation

Stainless steel tumblers were used as the electrodes. There are 16 electrodes 16 × 20 × 0.2 cm thickness, arranged as shown in Figure 1 in the form (+, 2N, -), where (+) represents the positive electrode, (N) is neutral, and (-) is the negative electrode. The gap between adjacent tumblers was adjusted using rubber gaskets. In addition, cover plates were made of acrylic to provide visual indication of electrolyte level. HHO cell is supplied with electrical energy from the engine battery which is recharged by the engine alternator. The cell productivity was tested without being connected to the engine with 2 different catalysts, KOH and NaOH, to find the best electrolyte with the best concentration experimentally.

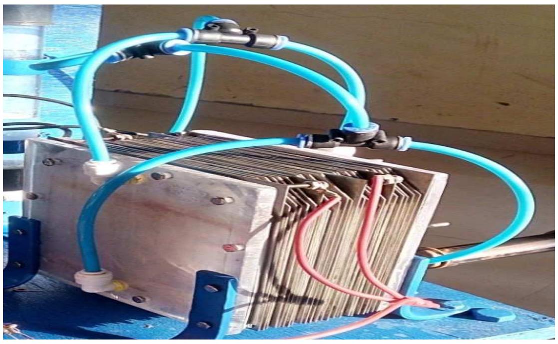

Figure 1: Electrolyser for Generating HHO Gas Showing the Plate Arrangement

Hydrogen and oxygen gases are directed to the engine intake manifold. According to the setup shown in Figure 2, the HHO gas leaves the separation tank and flows into the water open pool pushing the water down of the inverted graduated cylinder. The volume of gas collected in the graduated cylinder per unit of time was measured as the HHO flow rate. Therefore, the cell productivity can be calculated from the following equation:

HHO productivity = volume/Time (1)

First 1 litre of water was filled in the bottle, then KoH solution is added to the required amount. Around 3 to 6 grams of KoH was added to the water and the cap was closed tightly. The KoH salt was mixed with water thoroughly and poured into the HHO kit using funnel at certain level.

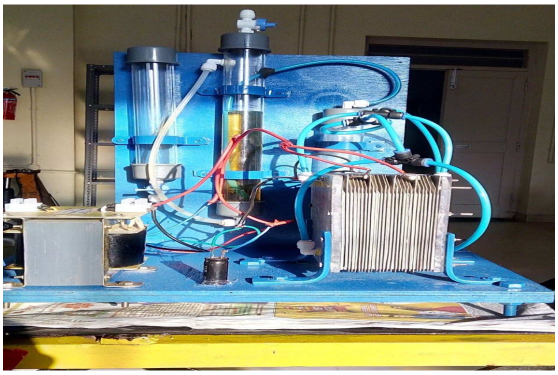

Figure 2: Setup for Calculating HHO Productivity

All the pipes are connected according to the required flow. Some amount of petrol is poured into the engine and the engine is started. by using ideal screw to maintain the ideal required rpm. The power supply kit is switched on. The gas generated from the kit is made to pass through the water bubbler. This enables any vapor content present in it to be removed. It is further passed through the petrol bubbler so that it can reduce the burning efficiency of hydrogen and increase burning capabilities of petrol and consumption of petrol is reduced. Then the fuel is connected to the intake of the engine by placing the flash back arrester to it.

When engine is started the throttle needs to be pulled continuously so that the required amount of air is sucked into the chamber and can burn the fuel continuously. The reading has to be noted and this process has to be done repeatedly and the time noted till the engine is run with and without HHO gas added to it. By using variation in KoH ion concentration the required gas flow can be achieved.

RESULTS AND DISCUSSIONS

Faraday's 1.24-volt minimum was based on the use of Battery Acid. It was discovered that a NaOH minimum voltage drop is 1.69, and KoH minimum voltage is 1.67. As it turns out, the electrolyte solution is affected by the voltage drop. Hence KoH solution was chosen based on the lower voltage drop. It can be calculated that from one plate, the production of H_2 is 0.035 lit min^{-1} while production of O_2 is 0.017 lit min^{-1}.

Total production of gas from one plate (HHO)

= 0.0348336+0.017402

= 0.0522356 lit min^{-1}

- The amount of gas generated from a HHO kit

  = 'N' * total amount of gas generated from each plate

- N = no. of plates = 24

  24*0.0522356

  = 1.2536 lit min^{-1}

6 small chips of KoH was established as optimum for the flow of gas to run the engine at a constant throttle. Table 1 shows the HHO gas evolution results. Maximum productivity is obtained when 6 g of KoH is added

(550 ml evolved in 29 seconds) while minimum productivity is obtained for 3 g of KoH (550 ml evolved in 53 seconds).

Table 1: HHO Gas Evolution Parameters Showing 6 g of KOH is Optimum for Gas Flow or Productivity

SL. NO	Amount of KOH (gms)	Voltage (volts)	Current (amp)	Resistance (ohm)	HHO Gas Generated ml/sec
1.	3 g	24	6.3	3.96	550/53
2.	4 g	24	6.8	3.52	550/48
3.	5 g	24	8.8	2.72	550/37
4.	6 g	24	10	2.4	550/29

Table 2 gives the engine specifications. For this configuration, the various parameters were calculated such as thermal efficiency, mechanical efficiency using hydrogen:petrol ratio 0.3:0.7 (corresponding calorific value was 30.6 MJ/kg) and the thermal efficiency was found to be 54.6% and the mechanical efficiency to be 69%.

Table 2: Engine Specifications

Engine Type	4 Stroke Single Cylinder OHC
Displacement	97.20 CC
Maximum Power	8.2bhp @ 8000rpm
Maximum Torque	7.95Nm @ 9000rpm
Bore And Stroke	50mm X 49.5mm
Compression Ratio	9.1:1
Idle Speed	1100RPM
No. Of Cylinders	1
Cooling System	Air Cooled

The HHO system was connected to the engine through a flashback arrestor as shown in Figure 3 and HHO gas was introduced at varying times during the combustion cycle. Correspondingly, the total engine running time was measured as shown in Table 3.

Table 3: Engine Performance with Addition of HHO Gas

Sl. No	Petrol (Ml)	Engine Running Time Approx. (Min)	Addition of Modified Hydrogen Gas to Combustion Cycle at Point of Time	Engine Running Time with Addition of Modified Hydrogen (Min)
1	20	4.13	NA	NA
2	20	4.13	At 3.17	4.13
3	20	4.13	At 2.44	4.53
4	20	4.13	At 4.10	4.24
5	18	3.5	At 2.3	4.44
6	15	3	At 2.50	4.31
7	15	3	At 2.3	4.14

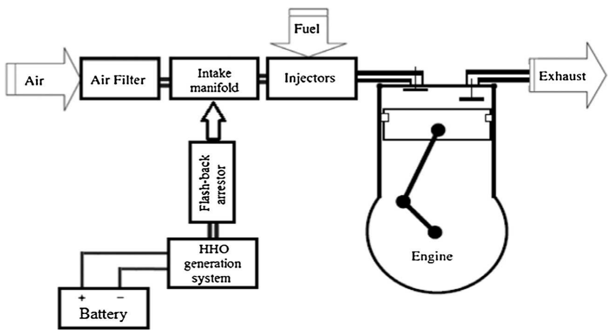

Figure 3: Arrangement to Connect the HHO Electrolyser to the Engine

From this it is observed that when HHO gas is introduced at 2.44 min, the engine running time reaches a peak of 4.53 min. It has to be noted that base running time of engine only with petrol is 4.13 min with 20 ml of petrol.

CONCLUSIONS

The use of H_2 or HHO produced by water electrolysis is investigated in gasoline engines. They provide advantages such as increased efficiency and peak pressure, and alleviate reduced mass of the cylinder charge. A hydrogen generator is designed and fabricated capable of delivering the required flow for optimum performance, and to be at an acceptable size and weight for installation on a passenger vehicle (such as a motorcycle engine). A thermal efficiency of 54.6% and mechanical efficiency of 69% was obtained.

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