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Hydrogen Operated Internal Combustion Engine

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Abstract: For the past decade, world has been facing serious depletion in the fossil fuels due to their abundant use with the growing population. Research is being conducted in order to find the best possible alternate fuels. Agricultural and rural areas have been contributing 40% of the global emission. Thus, the extensive use of fuels such as diesel and petrol can be restricted by using hydrogen gas as means of fuel for the small scale usage. There are many methods of producing hydrogen, however, electrolysis is the most economical way of producing hydrogen i.e. HHO. Hydrogen along with some amount of oxygen can be used in spark ignition engine as well as compressible ignition engine. This study is performed in activa engine i.e. 109cc.

I. INTRODUCTION

Fuel has always been one of the primary needs for human civilization. However, due to its abundant use there has been scarcity of fuel. Pollution has also been one of the issues that is being tackled globally. Conventional fuels used in vehicles and generators have resulted in release of toxic gases which leads to global warming. With the extinction of conventional fuels, different measures to find alternate fuels have been conducted. HHO gas can be used for this purpose. HHO gas can be produced economically through electrolysis.HHO gas is a zero emission fuel.

II. EXPERIMENTAL SETUP

A. Electrolytic Cell

The cell setup comprises of several components, of which some of them were considered by calculations and other by trial and error methods.

Stainless steel plates of grade 304 were used to make the electrolytic plates, the choice of the plate is based on the fact the SS 304 with-holds properties of being corrosion resistant and chemically inert to base in this case potassium hydroxide. The surface plates were sanded with grit paper grade 120 to increase the surface area for chemical reaction. The size of the plate was kept 100mm by 150mm. numbers of plates are 16 in number.

Plate configuration lies as follows

Two end plates are in direct contact with the positive terminal and two median plates are in direct contact with the negative terminals. The remaining 6 plates between the positive and negative plates act as neutral plates.

The reason for introducing neutral plates is that when Neutrals are introduced + space N space -.The same amount of current travels through each water area. Voltage is applied to only the end plates, positive and negative. The neutral plates actually cause a voltage drop. Each neutral cuts the applied voltage in half. It does this because it changes the resistance and spacing between positive and negative; which in turn changes the electrical pressure between neutral and positive and neutral and negative. If you measure the voltage from the positive plate to the negative plate, the reading will be 12 volts of electrical pressure. But if you measure from the neural plate to either positive or negative, the reading will be 6 volts of electrical pressure. Hence neutral plates are an effective way of lowering the plate voltage.

To restrict the flow of current to only selected parts, the plates were aligned and held together with nylon bolts, which was threaded according to the specific plate dimension and commercially available nuts. As a result of which the plate is aligned symmetrically in a very specific order. An attempt was made by using metal bolts which in turn made the electrolytic plates as resistance and not electrodes.

Pairs of plates are separated by rubber washers. This is done to maintain a consistent distance between the surfaces. This distance is 2mm. The length of the whole system is 152mm, width is 100mm and the total height of 150mm.

After designing the electrolytic cell, it was introduced into an air tight vessel which remained unaffected by the atmospheric changes. The material requirement for this vessel was nonconductive, chemically inert, high pressure sustaining, corrosion resistant and easily interchangeable in any catastrophic deformation. The commercially available PVC fittings with 160mm were equipped.

The bottom end of the vessel was sealed with end caps by using epoxy. Drainage valve was incorporated at the very end of the end cap. Frequent opening and closing of the vessel was necessary to check the conditions of the plates and other variables. For this purpose threaded end cap was used. The head of the end cap was incorporated with a supply valve, air vent, and HHO outlet. The

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head of the end cap was threaded for each of these fittings to ensure strength and air tightness of the vessel. Pair of holes was drilled (8mm) to make provision for positive and negative terminal of the cell and also these holes were acted to keep the plates intact and immersed at a consistent depth.

After standardization of the vessel specification, crucial devices like pressure gauge and shutoff valve for fuel supply was added. All the valve and fitting were made firm using a 2-part epoxy.

An oil seal introduces at the end of the threaded end cap, Teflon was used to secure the head to the vessel.

A special spanner was made to ease the turning of the head. This spanner also helped to tighten the joint of the head and body. The spanner of the head dimension is commercially unavailable.

From the electrolytic cell, HHO passes into a bubbler. Bubbler is an equipment which also acts as a safety guard. Hydrogen from the cell travels to the bubbler which comprises of three quarter water and quarter HHO.

Silicone pipes are the means of transferring the fuel from the electrolytic cell to bubbler and the rest of the components

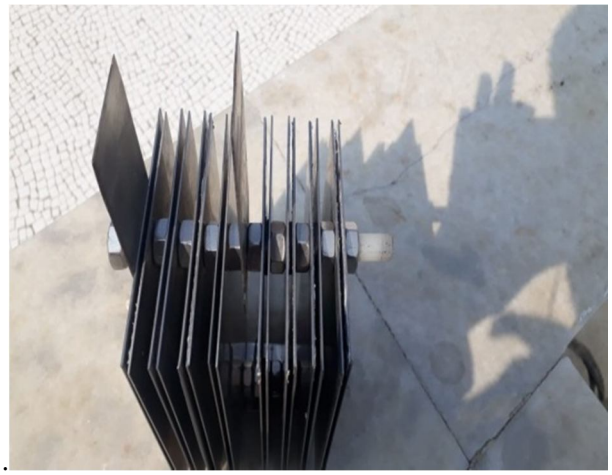


Fig 1. Electrolytic plates configuratiom

B. Engine Setup

Dismantled the body cover, chassis and other unnecessary components from the vehicle and disconnected unnecessary electronic systems. Before introducing the fuel into the engine necessary steps needs to be performed.

The steps are

1) In order to ensure smooth functioning and running of the systems, it is necessary to remove dirt and debris from the exterior surface of the engine. This could be started by cleaning carburettor which consists of pilot jet and main jet. Thus, both the jets were cleaned with petrol.
2) The hot heads and carbon deposits were thus removed for proper combustion and working of engine.
3) A new gasket kit was installed in the engine to ensure it is leak proof.
4) Engine oil needs to be changed as the engine is dismantled and new gasket kit has been installed. Thus it is necessary for the oil to reach every component of the engine.
5) Carburettor is used for creating a proper air fuel mixture in case of liquid fuels. However, in this case to use this carburettor it is necessary to seal off the overflow port and the vacuum pressure line in the intake manifold.

Introducing the fuel into the engine is the connection phase.

C. Offline Connection

The fuel is stored in compressible plastic bottle, by downward displacement method, valves and other auxiliary attachments are not kept. This setup is then attached to the open side of the carburettor. In downward water displacement method during a chemical reaction when gas is produced and the gas is lighter than water it will tend to displace the water in the delivery tube in the downward direction allowing the gas to collect on top of the water layer. This is an effective means to measure the volume of gas. Time was calculated to fill the volume of gas.

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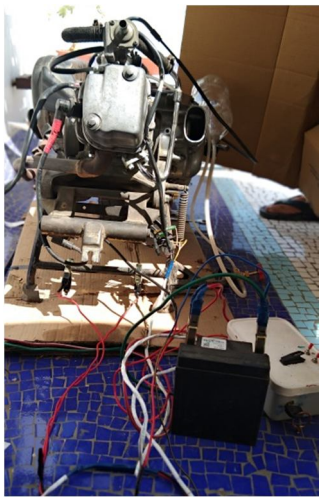


Fig 2. Offline connection.

III. OBSERVATION, RESULT & CALCULATION

Following table shows the rate of electrolysis, during all the run the electrolytic solution's concentration was unaltered at 10 grams in 1 L of water.

SR. NO.	SOURCE	VOLUME (ml)	TIME TAKEN (s)	VOLUME/SEC (ml/s)
1	SMPS	50	16.5	3.03
2	SMPS	50	16.67	2.99
3	SMPS	50	16.94	2.95
4	SMPS	1500	600	2.5
5	SMPS	1500	608	2.46
6	SMPS	1500	587	2.55
7	SMPS	1500	614	2.44
AVERAGE VOLUME/SEC (ml/s)				2.70
AVERAGE VOLUME/HOUR(L/Hr)				9.72

Table 1. Downward water displacement using SMPS

SR. NO.	SOURCE	VOLUME (mL)	TIME TAKEN(s)	VOLUME/SEC (mL/s)
1	CAR BATTERY	50	10.05	4.97
2	CAR BATTERY	50	10.12	4.94
3	CAR BATTERY	50	10.20	4.90
AVERAGE VOLUME/SEC (mL/s)				4.93
AVERAGE VOLUME/HOUR (L/Hr)				17.74*

Table 2. Downward water displacement using car battery

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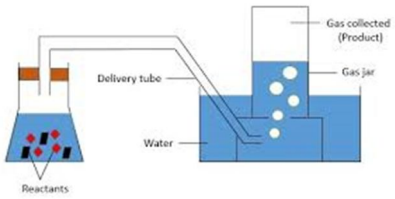


Fig 3. Gas syringe setup



Fig 4. Before and after supply of hydrogen during downward water displacement.

SR NO.	SOURCE	VOLUME (mL)	TIME TAKEN(s)	VOLUME/SEC (mL/s)
1	SMPS	10	3.70	2.70
2	SMPS	10	3.75	2.66
3	SPMS	10	3.71	2.69
AVERAGE VOLUME/SEC (mL/s)				2.68
4	CAR BATTERY	10	2.08	4.80
5	CAR BATTERY	10	2.08	4.80
6	CAR BATTERY	10	2.09	4.78
AVERAGE VOLUME/SEC (mL/s)				4.80

Table 3. Gas syringe method

A. Calculation of Air Fuel Ratio

Pressure at atmosphere: 1.01712 bars

Volume: 2.25litres

$PV=n_fRT$ where P=Pressure

V=Volume

n_f=moles of fuel

R= gas constant

T=Temperature

Volume of fuel= 1.5litres

$1.01712*1.5=n_f*0.08206*303.15$

$n_f=0.0615$

$n_f=n_{H2} + n_{O2}$

$n_f=2n_{o2} + n_{O2}$

$n_{O2}= 0.0613/3$

$n_{O2}=0.0204mol$

Therefore, number of moles in fuel i.e. HHO is 0.0613moles.

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Number of moles of oxygen in fuel is 0.0204moles
n_H=0.0409moles
Total volume=2.25L
Thus, for moles of air volume (V) =2.25-1.5
V=0.75litres
$PV=n_{air}RT$
$1.01712 * 0.75=n_{air} * 0.08206 * 303.15$
n_{air}= 0.0306moles
In 1litre of air at STP, there is 0.0094moles of oxygen is present
Therefore, for 0.75litre there is 0.00705moles present.
n_{O2}=0.00705moles
Total number of oxygen moles= 0.0204 + 0.00705
n_{O2}= 0.02745moles
Amount of oxygen= 0.8784g
Weight of dry air per mole=28.9647g
Amount of oxygen per mole= 0.20 * 32 (where, 0.20 is 20% of oxygen in air & 32 is molecular weight of Oxygen)
= 6.4g
If 28.967g of air contains 6.4g of oxygen
Then 0.08784g of oxygen will be present in 3.9g of air.
Thus the air fuel ratio= Air/Fuel=3.9/0.0818
= 48.5:1
The results of test runs conducted to start the engine are in the table below

SR. NO	METHOD OF IGNITION	DURATION (s)	A/F RATIO (MASS/MASS)	OBSERVATION
1	Kick Start	5	48.5:1	Successful
2	Kick Start	4	48.5:1	Successful
3	Kick Start	7	48.5:1	Successful
4	Battery	9	48.5:1	Successful
5	Battery	NA	20.8:1	Blast
6	Kick Start	NA	20.8:1	No Start
7	Kick Start	NA	20.8:1	Cold Start
8	Kick Start	8	48.5:1	Successful
9	Battery	NA	48.5:1	No start
10	Battery	10	48.5:1	Tachometer reading 835rpm
11	Battery	10	48.5:1	Tachometer reading 1020rpm
12	Battery	7	48.5:1	Blast Tachometer reading before blast 430rpm
13	Battery	NA	48.5:1	Cold Start
14	Battery	12	48.5:1	High yield run Rpm greater than 1020
15	Battery	14	48.5:1	Prolong running period by vary the valve setting near engine stall.
16	Battery	9	48.5:1	Blast occurring due to change of valve setting near the end.
17	Battery	9	20.8:1	Normal running at low rpm

Table 4. Test run results and observations

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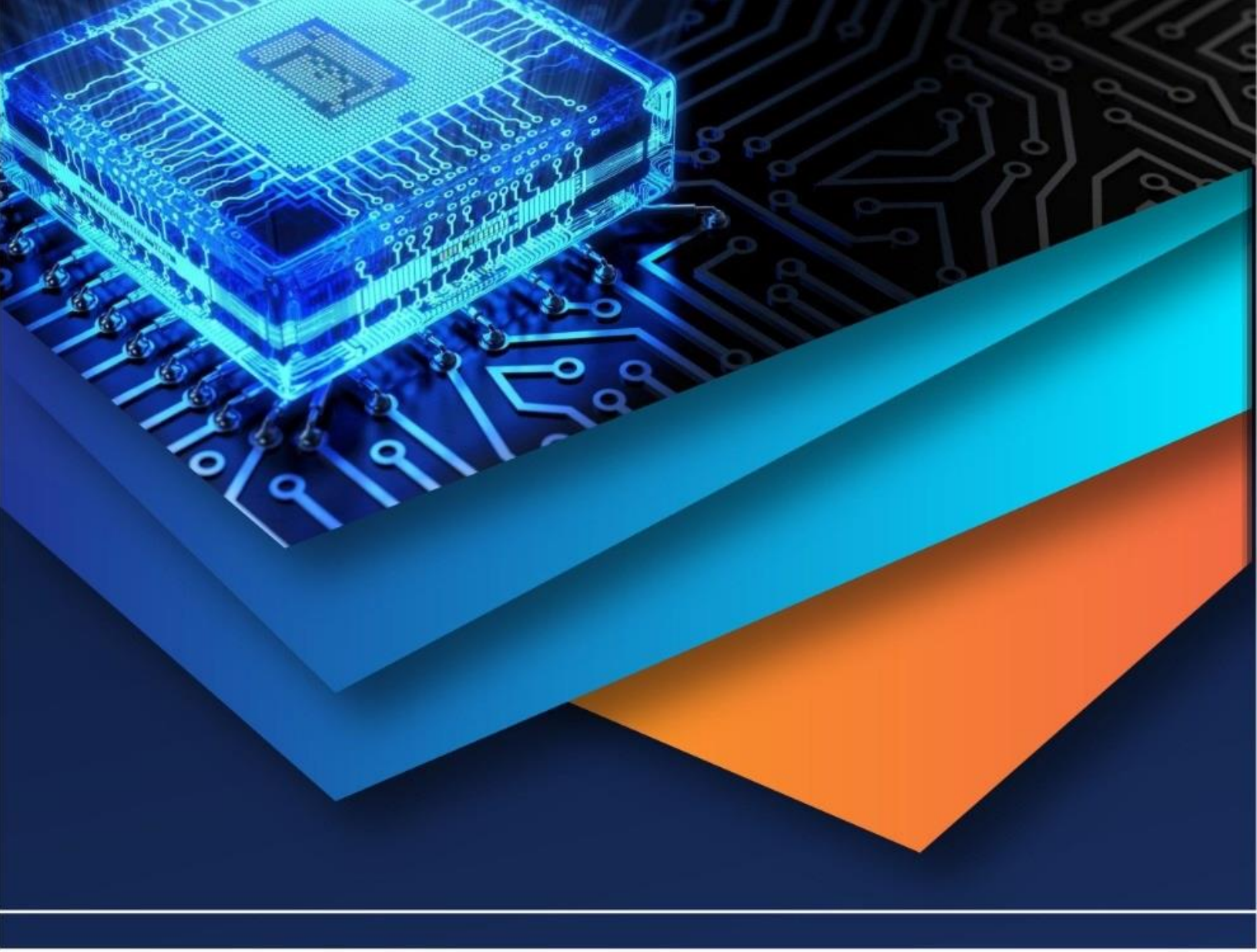
IV. CONCLUSION

This project proved to be successful in running the engine on hydrogen at idling rpm. It is feasible and economical to use hydrogen along with oxygen as an alternate fuel for small scale machineries. Hydrogen produced by electrolysis is the most efficient and effective method on site. HHO is a zero emission fuel, leaving behind 0% hydrocarbon and hardly detected CO_2 and CO levels. Utilizing hydrogen gas will contribute towards controlling the pollution and is much cheaper than diesel and petrol. The drawback to this system is the limited power source, in this project. Due to reduced power supply, the amount of hydrogen produced is insufficient to run the engine in an online configuration. Thus, on increasing the source this system can produce significant amount of HHO to run the engine constantly.

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