

Hydrogen as a Working Fuel in SI Engine

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ABSTRACT: With the threat of climate change it has become imperative to look for renewable sources of energy. One of the important thing about Hydrogen is its availability. It also has a wide range of flammability which allows very lean burning when compared to fossil fuels. Concept of using Hydrogen in any readily available SI engine has been proposed with some minor modification to the engine. The experiments were conducted on a CBZ bike(Honda 2000 model) with the engine size of 156cc with single cylinder. There was no changes done to the bike engine. The pipe connecting the fuel tank and carburettor was removed and instead of Petrol, Hydrogen from source was allowed to flow to the carburettor. The calculations pertaining to the amount of Hydrogen required per second for combustion in the engine have been done.

KEYWORDS: Hydrogen Fuelled SI engine, Air fuel ratio, Lean burn combustion, Stoichiometric A/F ratio.

I.INTRODUCTION

Usage of Hydrogen as a renewable source of energy has been considered for some time. Fast depleting reserves of fossil fuels and the man made actions leading to climate change make it important to look for alternative sources of energy. It is readily available in nature and makes it a desirable fuel. The current technology has its limitation because onboard storage is a problem. The production of H₂ by electrolysis is also not practical because amount generated by onboard production is not sufficient. Major drawbacks also include high pressure and temperature in the cylinder as well as higher NO_x emissions and self-ignition temperature attainment[1-5].

II.EXPERIMENTAL SETUP

The Experiment was carried on the CBZ engine which has the following specifications.

- Test Engine.

Displacement	156.80 ccm
Engine Type	Single cylinder, Four Stroke
Compression Ratio	8.5:1
Valves per cylinder	2
Torque	12.5 Nm

III. METHODOLOGY

Hydrogen usage has been studied widely by many researchers. Properties of hydrogen has been shown in table 1[6]. We see that the auto-ignition temperature of H₂ gas is more than that of petrol. For onboard production the electrolysis equation was used[7]. The Fuel/Air ratio for H₂ has to be lean and at constant torque it is observed that engine efficiency increases with decrease in Fuel/Air ratio[8]. Using direct injection of H₂ in intake manifold

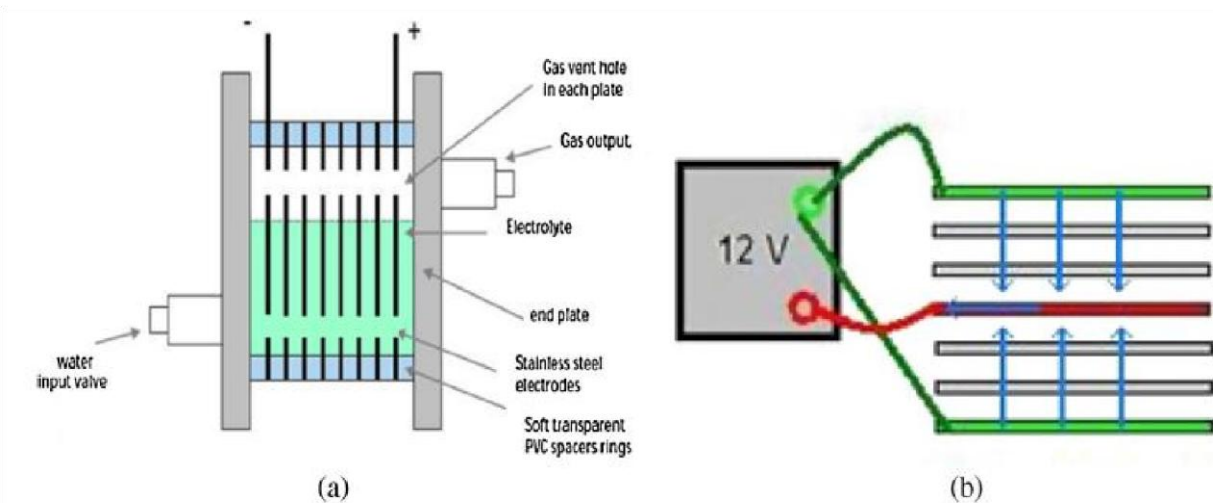
prevents pre-ignition, but pre-ignition inside combustion chamber may not be prevented[9]. Variations in spark plug gap and its changes in properties, also the NO emission changes due to different spark plug gaps are seen[10]. Backfire can be controlled by retardation of inlet valve opening but not in exhaust valve closing is not effective. Temperature was below NO_x generation temperature and NO_x emission achieved was less than pollution level[11]. Figure 1 below shows the experimental setup of the test engine. Some undesirable combustion characteristics such as pre-ignition, back fire, misfire, auto ignition, knocking etc. can occur during the running of the engine. There are two sources of Hydrogen that can be used in the engine:

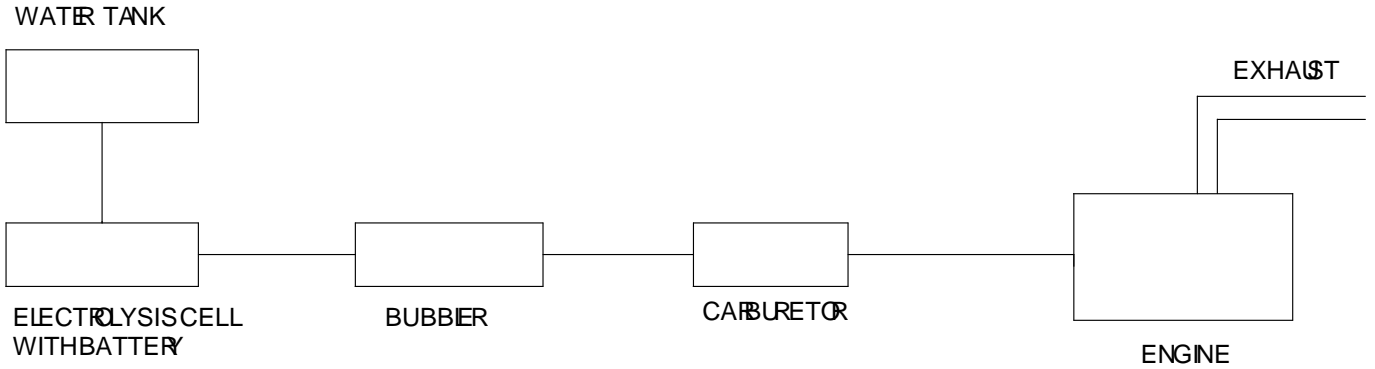
1. By Electrolysis of water
2. By using pressurised Hydrogen gas.
3. By using Hydrogen Fuel Cell.

Setup of electrolysis cell [15] :

HHO Cell materials required	Quantity	Dimensions in mm
Stainless steel plates as electrodes	7	160*200*2
Bolt and Nut required	As per requirement	D= 6-8 mm & L= 75 mm
Rubber gasket	8	1mm thickness
Acrylic cover plate	2	200*240*10
KOH or NaOH	KOH- 6g/l & NaOH- 4g/l	-
12V DC Battery	1	-

The 7 stainless steel electrodes are placed alternately with one positive, two neutral plates and one negative with this combination repeating. There are two acrylic sheets on both ends of the cell. The setup is shown in the figures (a) , (b) & (c) below [15]:





(c)

By using Hydrogen cylinder:

The setup using hydrogen cylinder is shown in the below figure(1) :

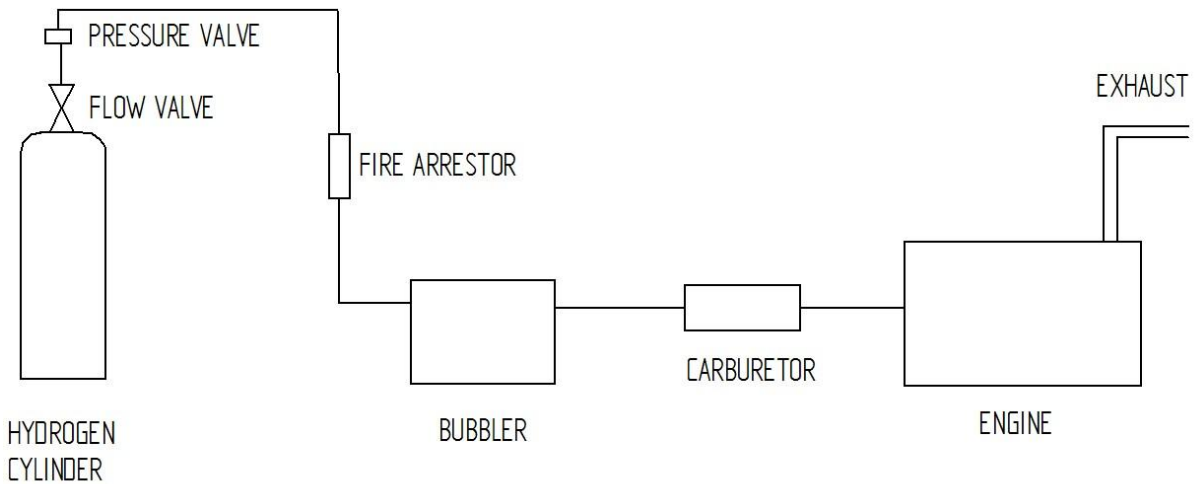


Figure 1: Experimental Setup

By using Hydrogen Fuel cell

Hydrogen Fuel cell is also an option to generate the desired hydrogen as a fuel, but since this method is not cost effective this method is not been tried.

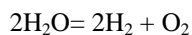
Table 1: Comparison of properties of hydrogen and petrol

Properties	Hydrogen	Petrol
Auto Ignition Temperature, K	858	501-744
Flame temp. in air, K	2318	2470
Quenching Gap in NTP air, cm	0.064	0.2
Equivalence Ratio	0.1-7.1	0.7-3.8
Max. energy for ignition in air, MJ	0.02	0.24

Calculation of Stoichiometric Ratio:

The theoretical or stoichiometric combustion of hydrogen and oxygen is given as

Air/Fuel Ratio [12]:



Moles of H₂ for complete combustion = 2 Moles

Moles of O₂ for complete combustion = 1 Moles

Moles of N₂ in air = 3.762 Moles

Total no of Moles in air = 4.762 Moles

Wt. Of O₂ and N₂ = 32g and 105.33g

Wt. Of Air = 137.33g

Wt. Of Hydrogen = 4g

Stoichiometric Air/Fuel Ratio of Hydrogen and Air is

$$\begin{aligned} \text{A/F based on mass} &= \text{mass of Air/mass of Fuel} \\ &= 137.33\text{g}/4\text{g} \\ &= 34.33:1 \end{aligned}$$

IV DEMERITS

1. Due to very low density (0.09 kg/m³) it has very low volumetric energy density and hence onboard storage requires very large volume for a given mass.
2. Hydrogen vehicle will be effective for its low pollution level, but it also produces toxic emissions of NO_x.

V. PRECAUTIONS

1. Hydrogen should not accumulate under the roof or overhang where it forms an explosion hazard.
2. Using rich Air/Fuel ratio and reducing peak cylinder pressure helps in prevention of knocking.[14]
3. Wear protective clothing to avoid accidents while working with hydrogen and KOH.[13]
4. Use of fire safety equipments.

V. CONCLUSION

Electrolytic cell and Hydrogen cylinder both can be used as a source of fuel to run SI engine.

In case of the electrolytic cell, when Hydrogen liberated from the cell was used in the engine, due to the mixing with the air in the manifold a very lean mixture was formed which hampered the running of the engines.

Demerits of using the cell

1. Manufacture of the cell is not an easy task.
2. Additional cost of additive electrolyte.
3. Battery size in the two wheeler is not compatible for the generation of sufficient Hydrogen.

While on the other hand use of hydrogen cylinder gave appreciable results. Initial cost of this cylinder as approximately the same as the cell but is more effective.

An approximate mileage of this vehicle is 130KmPL. This average of the vehicle will help retaining the initial cost more effectively.

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