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Hydrogen Fueled Engine

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Abstract*— *Hydrogen is a very reliable and abundant source of energy for the future generation. As the time passes by, the quantity of fossil fuel left will drastically fall and this will hike up the requirement of alternative fuel and hydrogen will be the most demanding of all. An IC engine of an automobile uses most of the fossil fuels which is being extracted and we can't replace the existence of an IC engine with another engine so easily due to its large quantity, so this paper introduce the simplest way to use Hydrogen fuel in an IC engine by doing minimal modifications to engine.

***Keywords*— *Hydrogen kit, hydrogen fuel, hydrogen IC engine, hydrogen fueled engine*.**

I. Introduction

The pollution caused due to burning of fossil fuels (i.e.: CO_2, NO_x, CO, HC) is very harmful to our environment and other living beings. The major cause of Global warming is CO_2. A Hydrogen based fuel engine is very effective to remove these emissions from the exhaust. The by-product formed due to burning of hydrogen is H_2O and some sort of NO_x inside an IC engine. The fuel line of an automobile is designed to carry liquid fuel like petrol and diesel from tank to combustion chamber. Hydrogen is a gaseous fuel and highly flammable so we need to build a fuel line which is capable to handle such amount of pressure and allow us to control the fuel rate entering the combustion chamber.

II. Litrature

A hydrogen internal combustion engine (HICE) is a type of engine which uses hydrogen as a fuel and a very small number of vehicle uses this kind of engines. Hydrogen internal combustion engine are different from hydrogen fuel cell which uses electrochemical conversion of hydrogen rather than combustion, the hydrogen internal combustion engine is simply a modified version of the traditional gasoline-powered internal combustion engine.

The earliest attempt for developing a hydrogen engine was reported by Reverend W. Cecil in 1820. Cecil presented his work before the Cambridge Philosophical Society in a paper entitled "On the Application of Hydrogen Gas to Produce Moving Power in Machinery." The engine itself operated on the vacuum principle, in which atmospheric pressure drives a piston back against a vacuum to produce power. The vacuum is created by burning a hydrogen-air mixture, allowing it to expand and then cool. Although the engine ran satisfactorily, vacuum engines never became practical.

In the 1860s and 1870s, N. A. Otto (the inventor of the Otto cycle) reportedly used a synthetic producer gas for fuel, which probably had a hydrogen content of over 50%. Otto also experimented with gasoline, but found it dangerous to work with, prompting him to return to using gaseous fuels. The development of the carburettors, however, initiated a new era in which gasoline could be used both practically and safely, and interest in other fuels subsided.

Hydrogen has since been used extensively in the space pro-gram since it has the best energy-to-weight ratio of any fuel. Liquid hydrogen is the fuel of choice for rocket engines, and has been utilized in the upper stages of launch vehicles on many space missions including the Apollo missions to the moon, Skylab, the Viking missions to Mars and the Voyager mission to Saturn [1].

In recent years, the concern for cleaner air, along with stricter air pollution regulation and the desire to reduce the dependency on fossil fuels have rekindled the interest in hydrogen as a vehicular fuel so we need to adopt the usage of hydrogen in our life {2}.

A. Hydrogen Properties

Hydrogen gas is highly flammable and will burn in a wide range of air concentration, from 4% to 75% by volume and the temperature of spontaneous ignition in air, is 500 °C (932 °F) [3].

The enthalpy of combustion is 286 kJ/mole and reaction goes like

$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l) + 572\ kJ\ (286\ kJ/mole)$ [4]

The properties that contribute to its use as a combustible fuel better than gasoline are its wide range of flammability, low ignition energy, small quenching distance, high auto ignition temperature, high flame speed at stoichiometric ratios, high diffusivity, very low density[5][6][7].

The stoichiometric A/F ratio for the complete combustion of hydrogen in air is about 34:1 by mass [8].

Since both the carburetted and port injection methods mix the fuel and air prior to it entering the combustion chamber, these systems limit the maximum theoretical power obtain-able to approximately 85% of that of gasoline engines. For direct injection systems, which mix the fuel with the air after the intake valve has closed (and thus the combustion chamber has 100% air), the maximum output of the engine can be approximately 15% higher than that for gasoline engines [1].

1 gallon of gasoline has an energy content of about 130 Mega Joules (MJ) and 1 kg of H_2 is in the same range (130 to 140 MJ). The calorific value of gasoline is 44.5MJ/Kg and that of Hydrogen is 119.9 MJ/Kg. [9]

At first glance, it would appear that they are pretty much equal, except that H_2 costs several dollars per kg just to produce ($4.50, according to the National Renewable Energy Laboratory), which must be done using renewable energy as the original power source if we are to get any real benefit from using the H_2[10].

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III. HYDROGEN KIT LAYOUT

The experiment takes place using a Pulsar 220 cc 4 stroke engine.

Port injection has been used to inject the hydrogen because it is a carburetted engine. The injection of hydrogen is done using a nozzle which is fixed in a drilled hole between the carburettor and intake port of the engine. In case of hydrogen injection, the carburettor works as a throttle body and only used to control the air going inside the engine cylinder.

There is no change done to the stock engine, we have just added a tank which stores hydrogen and a hydrogen fuel line through which hydrogen is supplied into the intake port of the engine.

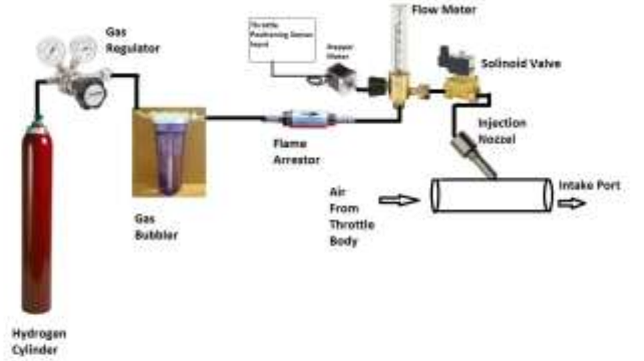

Fig. 1. Hydrogen fuel line.

The above Fig. 1. Represents the fuel line which has been used to test the engine. The hydrogen tank holds hydrogen at high pressure and the pressure is controlled by the gas regulator and then the gas passes through a gas bubbler which provides a visual representation of the gas flow and then a flame arrestor is installed to stop the back fire if occurred. A flow meter is used after the flame arrestor to measure the gas flow and the regulator of the flow meter is connected to a stepper motor whose input source is the throttle positioning sensor so that the gas flow can be controlled through the throttle itself. Then a solenoid valve is used to cut off the gas flow when the engine is turned off and then after the gas is injected through a nozzle fixed in a drilled hole between throttle body and intake port.

The parts used in Fig. 1. Just for the purpose of testing and the final simplified design of hydrogen kit which can be used in commercial vehicle is given in Fig. 2.

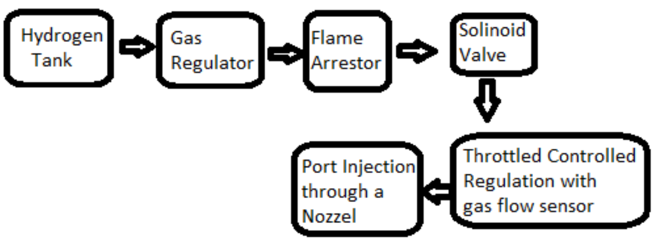

Fig. 2. Hydrogen fuel line final layout.

In Fig. 2. The simplified version of fuel line is described which can be used in a vehicle, the gas bubbler and the flow meter is removed and a flow sensor in installed in place of it. The injection mechanism can vary for different engine configuration and it can also be injected directly in injector based engines but in carburetted engines, port injection is the best method.

IV. EXPERIMENT RESULTS

The engine testing is done on a dynamometer at a constant engine R.P.M of 2500. The testing is done using petrol and hydrogen fuel respectively.

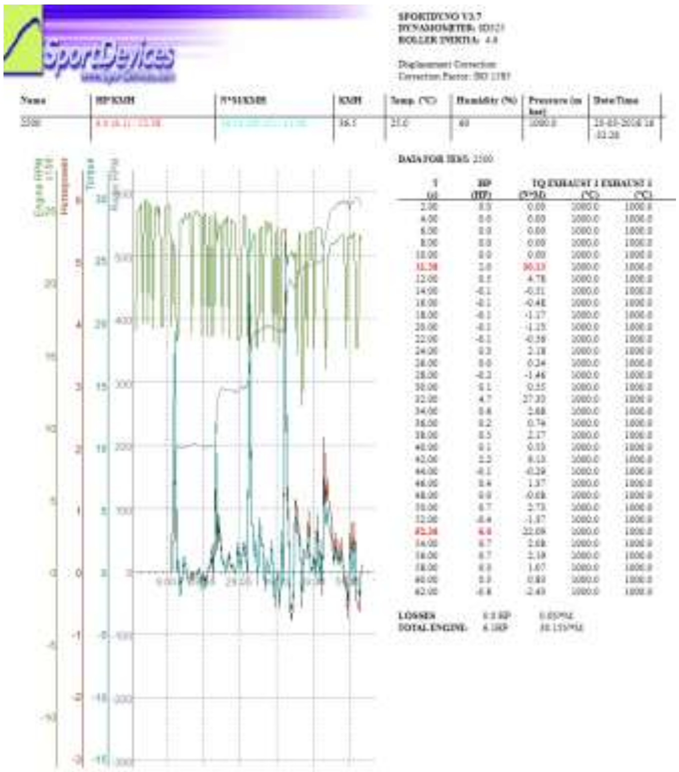

Fig. 3. Test result on petrol fuel.

Fig. 3 Show the test results done on petrol fuel. In the graphical portion, the y-axis represents time and in x-axis there are 4 variables which are, engine R.P.M. in green, Horsepower in red, Torque in Blue and Roller R.P.M in white.

The testing is done at a constant engine R.P.M. of 2500 and the gear has been shifted from neutral to 5th gear in every 10 to 15 seconds.

Table I given a proper comparison of the resultant value of petrol and hydrogen, giving its maximum output of Power, Torque and Speed.

TABLE I. Comparison of results.

S. No.	Engine at 2500 R.P.M.		
		Petrol	**Hydrogen**
1	**Horsepower(HP)**	6.0	5.3
2	**Torque(Nm)**	30.13	29.98
3	**Speed (km/hr.)**	36.5	33.2

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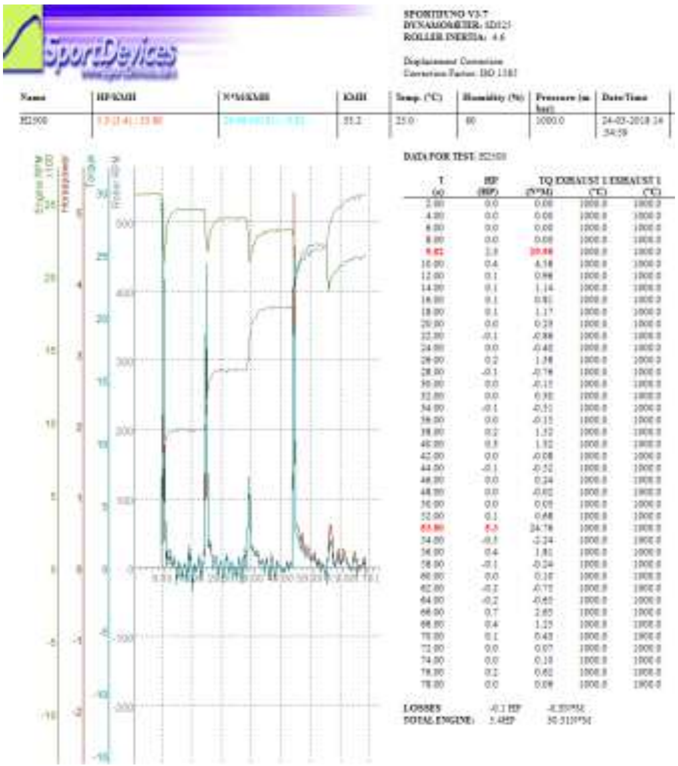

Fig. 4. Test result on hydrogen fuel.

The Fig. 4. Shows the resultant value of the engine at 2500 R.P.M. on hydrogen fuel.

V. CONCLUSION

So as we can see that it is possible to run an IC engine on Hydrogen without doing any major modifications. The resultant graphs and values shows that there is a very small difference in the output Power and Torque in between Petrol and Hydrogen fuel. So this Hydrogen can be the best alternative potion for the fuel used in IC engine and it can solve the problem of fuel crisis in coming years.

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