International Journal of Scientific & Engineering Research, Volume 8, Issue 3, March-2017
ISSN 2229-5518

Hydrogen as a fuel for automotive engines: A Review

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Abstract **- Literature review of various papers on usage of hydrogen of fuel & its characteristics are discussed in this paper. The main focus is kept on the optimization aspects for stabilization of hydrogen production process and its usage and hence only such research works are included in this work in which the use of advanced techniques like fuel-cell storage & electrolysis generation of hydrogen were involved.**

Index terms **- Conventional fuel, hydrogen, global warming, emissions.**

I. INTRODUCTION

Mobility is one of the most important fundamental desires of human beings. In the future, it is likely to expand further along with the progress of the world economy. Also there is an increase in demand of mobility everywhere in the world. Environmental issues like global warming & exhaust emissions are raised by the increase of personal mobility mainly derived from automobiles.

From the world total energy about one quarter of it is consumed by transportation. In the case of internal combustion engines, due to frictional loss & exhaust gas, a large amount of fuel energy is emitted as heat, which is pure wastage of energy.

As the time is progressing so is the need for more efficient fuel having a better quality compared to conventional fuel. There is a need for a fuel that is clean, sustainable, renewable & economical. This can be achieved by using hydrogen as a fuel.

Hydrogen is available abundantly in the nature in compound form. After the fossil fuels, it is expected to be a recyclable energy carrier. It can be used in CI & SI kind of engine. Hydrogen has various advantages over the conventional fuels except for the production, storage & transportation.

Hydrogen is produced by a hydrogen-generation unit, which is carried out by simple electrolysis of water with some additives. The fuel so produced can either be stored in gaseous form or in metal sponge form by adsorption or supplied directly to the internal combustion engine by mixing it with air using a specially designed carburetor. The emission so produced would be pure water coming out of exhaust. This will not have any negative impacts on the environment. Also there is not any need for a refueling station if there is an on-board hydrogen generating unit. Although it has higher initial price but has lower maintenance cost as well as longer life.

II. LITERATURE SURVEY

In paper [1] the author explained that hydrogen shows the solution and also allows the progressive and non-traumatic transition of today's energy sources towards feasible, safe, reliable and completely sustainable energy chains. There are sufficient environmental and public health benefits of direct hydrogen fuel to justify moving ahead based on what we know already about fossil fuels, their consequences and their limitations. The author also mentioned that the coming decade will definitely see much greater use of ''Green Power'' so as to ensure less dependence on 'Fossil Fuels' and also in order to prevent environmental degradation and global warming.

In paper [2] they explained about the challenges associated with the storage of hydrogen. They gave us explanations about the various technologies associated with the storage of hydrogen and the various parameters involved. These technologies include storage of hydrogen in gaseous, liquid as well as in solid form.

In paper [3] they has explained that, due to low volumetric efficiencies and frequent pre-ignition combustion events, the power densities of premixed or port-fuel-injected hydrogen engines are diminished relative to gasoline-fueled engines. They also mentioned that there has been significant progress made in the development of advanced hydrogen engines with improved power densities.

In paper [4] they explained that after some modification in existing SI and CI engines, we can use hydrogen as fuel and also run the engine with mixture of hydrogen in petroleum and diesel products. In fuel injection systems, Direct in Cylinder Injection (DCI) or (DI) is better than Inlet manifold & Port injection and Fuel Carburetion Method (FCM) or (CMI). The power loss in hydrogen engine can be compensated by using super charger.

In paper [5] they explained about the usage of hydrogen as an alternative fuel. They also mentioned about its use in SI and CI engines. They performed test on diesel engine & results showed that the thermal efficiency increases with increase in percentage of hydrogen for constant speed & load. The brake thermal efficiency is increased near by the richest condition & then decreases with increase of Air fuel ratio. They conclude that hydrogen usage in CI or SI engine gives impact on the brake thermal efficiency & brake power, the emission of NOx is reduced as well as HC, CO, CO_2 at the lean mixture.

In paper [6] they explained about difference between hydrogen & gasoline on basis of cost & remaining amount of fossil fuel on earth. They mentioned that hydrogen has the best energy-to-weight ratio compared to any fuel. Also, hydrogen when used in fuelled engine, it has more concerning power & efficiency, also less emission. They explained that hydrogen fuelled SI engine has some drawbacks of high NOx emission & small power output determined by performance. They conclude that hydrogen is an additive to a hydrocarbon fuel. It can be mixed with other high pressure natural gases & can store in one tank.

III. LITERATURE OUTCOMES

Hydrogen can be use in SI and CI with proper modification in engine and changes in properties of hydrogen. It can be stored in high pressure tanks or in the form of metal hydrides. In hydrogen engine, power & torque is less at low speed and gives better performance at higher speed. Emission of HC, CO , CO2 is reduced. NOx emission is very less is 9-10 times lower than gasoline. The pre-ignition problems are solved & solutions such as fuel delivery systems, thermal dilution, engine design, ignition system, crankcase ventilation, thermal efficiency, emission & power output are

obtained. Its eco-friendly to environment. Hydrogen is a better alternative as a fuel.

IV. Scientific Analysis

Table 1 – Heat of combustion of various fuels.

Fuel	Energy (Kcal/g)
Hydrogen	34.0
Petroleum	10.3—8.4
Paraffin	10.3—9.8
Graphite (Coal)	7.8
Castor oil	9.4
Wood	4.2

Table 2 – Hydrogen concentration in different systems.

System	Density (g/cm^3)	H atoms per unit volume ($\times 10^{22}/cm^3$)	Weight % H hydrogen
Liquid H_2	0.07	4.2	100.0
Gas	0.008	0.5	100.0
H_2O (Liquid)	1.0	6.7	11.2
H_2O (Liquid)	0.6	6.7	18.0
$FeTiH_2$	5.6	6.2	1.9
$LaNi_5h_6$	6.5	7.0	1.4
VH_2	5.0	11.2	2.1
MgH_2	1.4	6.7	7.6

Hydrogen has established it as a viable source of energy and scientists all over world are involved in making it commercially available source of energy because of its environmentally friendly nature.

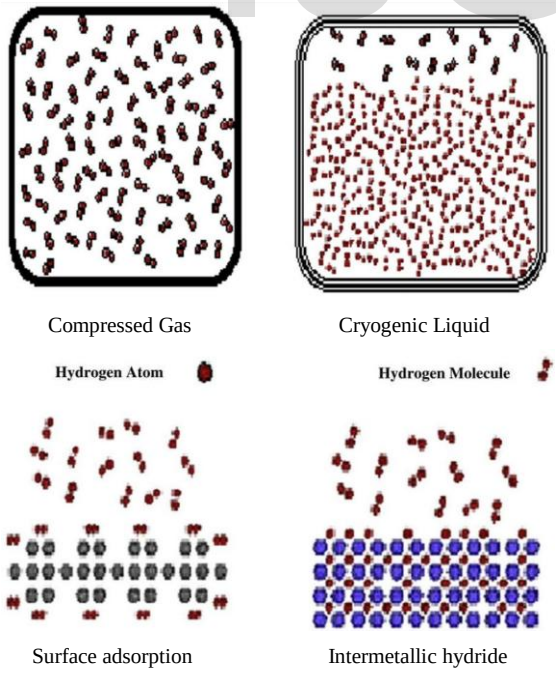

Fig. 1 - Hydrogen in gas, liquid & in metal hydrides.

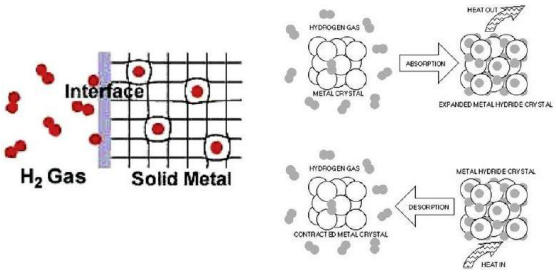

Fig. 2 - Simplified model of metal–hydrogen interaction.

V. Conclusion

This paper concludes that there is an immediate need for scientific community across the world to realize the very much importance of hydrogen energy as a viable alternative to fossil fuels & hence find suitable solutions for the same.

Hydrogen is useful for any type of application, be it industrial, domestic or any of the following shown below:

- Produce Electricity: using fuel cells.
- Cook Food: using hydrogen burner
- Drive Car: Gas, Liquid or metal hydride can provide Hydrogen Gas.
- Run Factories:
- Jet Plane and Space Craft
- Hydrogen Village.
- Personal Use: Domestic Power, Mobile Phones, Watches, Laptops, Computers, Calculators, etc.

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