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A Review on Implementing Hydrogen Engine- A Case Study of India

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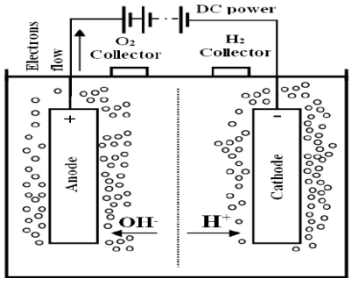
ABSTRACT:- In the present scenery gasoline vehicle are producing measure pollutants like carbon dioxide, oxides of nitrogen, oxides sulphur& particulate matter which are increases global warming. Hydrogen is ultimate fluid overcome automobile pollution by emitting only water. But the challenge in Indian market is production of hydrogen, storages, filling stations and hydrogen engines. Promoting companies to setup their plants with subsidies .Automobile sectors are advised to production of hydrogen engine. A manual engineering technology for setup or replacing filling station in each part of country .Reduction of global warming is reduced 2-5% by increasing use of hydrogen vehicle.

1. INTRODUCTION:- Just like note ban it is impossible to stop all the gasoline vehicle and replacing hydrogen vehicle .It is slow and steady process just country like India which development is still going. Hydrogen will be the most widely used fuel in coming 10 to 15 years .Presently cheapest hydrogen is steam reforming of methane where CO2 reduction is completely not possible .Other procedure like electrolysis, photolytic & thermal process. But still the research is going on producing pure hydrogen. Not only the producing storage handling is little bit use but also cannot detect easily as it is a colorless & odorless gas. Just similar to ICEs of gasoline hydrogen engine are similar way of combustion. Hydrogen engines are higher performances than only at lighter engine load. By increasing load stoichiometric ratio in case of heavy load engine production NOx increases which is under the research(Castro, Toledo, & Amador, 2019).(Kalamaras & Efstathiou, 2013)

2. PRODUTION OF HYDROGEN: -

2.1. ELECTROLYSIS: -This is very first procedure for the production of hydrogen by decomposition of water into oxygen and hydrogen where current supply starts from 1.23v.process having one cathode and anode both are supplied with electric current, when pure water are supplied to the chamber $+_{ve}$ ion of H_2 will passes towards cathode and upper part of the chamber are fitted with a container to store hydrogen. Another part is -ve ion of O2 is attracted towards anode O2 gases are collected in a container.



Reactions are

Anode(oxidation): $2H_2O(l) \rightarrow O_2(g)+4H^+(aq)+ 4e^-$

Cathode(reduction): $2H^+(aq) + 2e^- \rightarrow H2(g)$

But still the research is going on for better electrode, getting pure water, voltage stability for better accuarcy. It also helps in the production of oxygen also consideration about better oxygen.(Carmo & Fritz, 2013)

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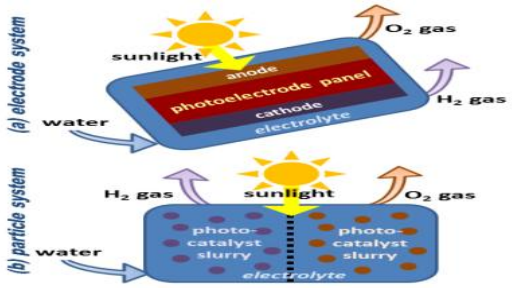
2.2. PHOTOLYTIC PROCESS

2.2.1 Photoelectrochemical Hydrogen Production (Using Solar Power to Directly Split Water): In this process photoelectrochemical material (semiconductor) dissociates water into hydrogen and oxygen by using sunlight.PEC materials are same those are used in photovoltaic solar cell.PEC directly convert solar energy into chemical energy. This is good technology for production hydrogen by using solar energy instead of electricity but the rate of production hydrogen is very low. It is only applicable in day time.(Alfaifi, Ullah, Alfaifi, & Tahir, 2018)



2.2.2 BiologicalHydrogen Production (Photobiological Water Splitting): These are several types are described bellow.

2.2.3 Dierect biophotolysis: In this process fresh water algae are used for H_2 and O_2 production by using solar energy directly converted into chemical energy. Also seawater algae are used for the H_2 production . *chlamydomonas reinhardtii* is the microbe commonly used microbe, *Scenedesmus obliquus* and *Chlorella fusca* are used.(Hallenbeck et al., 2019)

$$2H_2O + \text{light energy} = 2H_2 + O_2$$

2.2.4 Indirect biophotolysis: In this process H_2 and O_2 are produced two steps starting form photosynthesis to sugar formention. Cyanobacteria from the species of *Anabaena , Oscillatoria , Calothrix* and *Gloeocapsa* are mainly used.(Alfaifi et al., 2018)

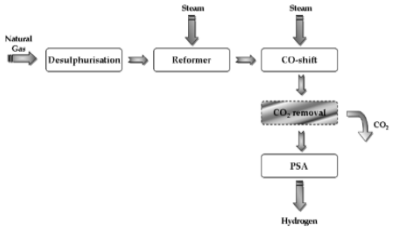
$$6\ H_2O + 6CO_2 + \text{light energy} \rightarrow (C_6H_{12}O_6)_n + 6\ O_2$$

$$(C_6H_{12}O_6)_n + 12\ H_2O + \text{light energy} \rightarrow 12\ H_2 + 6\ CO_2$$

2.3. THERMAL PROCESS

2.3.1. Distributed Natural Gas Reforming: This is most widely used hydrogen production .A large scale of production of hydrogen in USA in this process. 700˚C-1000˚C steam is passed to methane for producing hydrogen under a pressure of 3-25 bar.(Kalamaras & Efstathiou, 2013)

$$CH_4 + H_2O\ (+ \text{heat}) \rightarrow CO + 3H_2$$



2.3.2. Bio-Derived Liquids Reforming: these are the procedure for hydrogen production on sites, in this biomass by process of thermo chemical produced into bio-oil then by stream reforming to convert into hydrogen("Bio-Derived Liquids to Hydrogen Distributed Reforming Working Group (BILIWG), Hydrogen Separation and Purification Working Group (PURIWG) & Hydrogen Production Technical Team Research Review 2007 Ann ual and Merit Review Reports," 2007)

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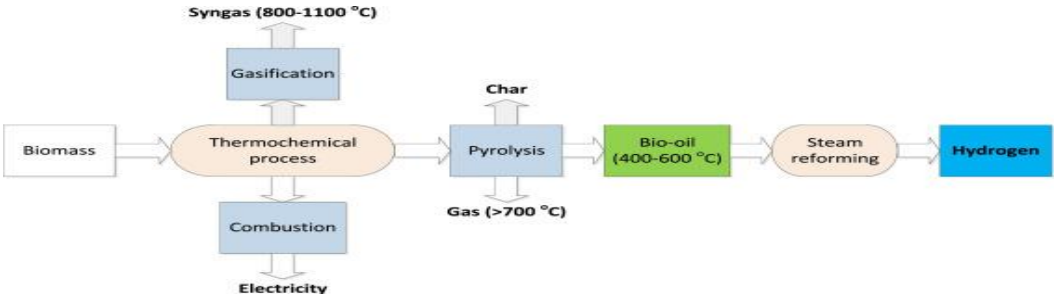

STORAGE : The six basic hydrogen storage and methods. The gravimetric density p_m, volumetric density p_v,working temperature T and pressure P are listed. RT = room temperature at 25˚C .(Abe, Popoola, Ajenifuja, & Popoola, 2019)

Storage method	p_m [mass%]	p_v [kg H_2 m^{-3}]	T [˚C]	P [bar]	Phenomena and remarks
High pressure gas cylinder	13	<40	RT	800	Compressed gas (molecule of H_2) in light weight composite cylinders(tensile strenght=2000MPa)
Liquid hydrogen in cryogenic tanks	Site dependent	70.8	-252	1	Liquid H_2 , contious loss of few % of hydrogen per day at RT
Adsorbed hydrogen	=2	20	-80	100	Physisorption (molecule of H_2) on materials , e.g. carbon with very large specific surface area, fully reversible
Absorbed on interstitial in a host material	=2	150	RT	1	Hydrogen (atomic H) intercalation in host metals, metalic hydrides working at RT are fully reversible
Complex compound	<18	150	100	1	Complex compound ($[ALH_4]^-$ or $[BH_4]^-$), desorption at elevated temperature , adsorption at high pressure.
Material and complexes togeather with water	<40	>150	RT	1	Chemical oxidation of metal with water & liberation of H_2 , not directly reversible .

3. TANKS : First hydrogen tank was 700bars (70MPa,10000 Psi) was introduced in 2014.further recently Hy-Can tank was constructed for the 1 liter,10 bar format. A classification of hydrogen tank are metal tank (steel/aluminium) where aluminium/glass having 263bar,steel/carbon 299bar.Later composite tank fiberglass/aramid or carbon fiber with metal liner(Al & steel) such as Aluminum/glass-305bar, Aluminum/aramide -438bar, Al/Carbon -700bar again only introduction of carbon fiber with polymer liner of 700bars.(Zhang, Lv, Kang, & Zhou, 2019)

4. Hydrogen filling station : In India there should be primarly hydrogen station start from the urban areas by just rearrange the setup the petrol pump.(Thesen & Langhelle, 2009)
How to construct a hydrogen station ?
Layout for each and every part of staion , it must have for both light and heavy vehicle. Basically 2 types of hydrogen are available H70(10000Psi) and H35 (5000Psi) are accodingly specialised engine . Component of a stations are

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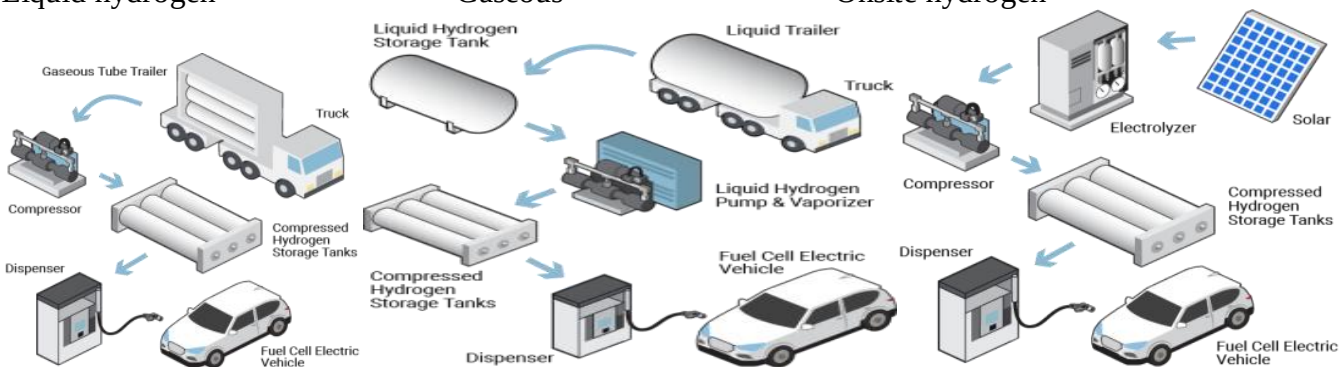
Hydrogen stoare equipment: Based onlocation and capacity,hydrogen can be stored a liquid , a low [pressure & high pressure gas.Tank must follows ASME standard.
Compressor : Compressor are used reduced volume and increases pressure (replenish the buffer strong) , liquid and low pressure gas hydrogen station may uses multiple compressor.
Chiller :Hydrogen need cooling, not to exceed the thresold temperature of industry standard fueling protocol.
Dispenser : Must have one or more accodingly hydrogen requirement in there locality.

Liquid hydrogen Gaseous Onsite hydrogen



5. Hydrogen Engine :

Since 1976 hydrogen engine are great impact . Hydrogen engine has 3 primary obstracles safety, infrastructure and cost. It is lighter than air weight reduction as compared to gasoline engine. If any hole in the cylinder , it doesnot explosion simply escape and dissolve in atmosphere . Hydrogen is preety much higher host than gasoline engine as high stress material are used.(Castro et al., 2019)(Deheri, Acharya, Thatoi, & Mohanty, 2020)

6. Function :

From the filling station hydrogen are received with receiver pipe with a special arrangement of intake valve where a spring arrangement of rod open.After filling rod gets its original position .Hydrogen are stored in the tank then supply to engine by mixing with air in carburetor or fuel injector to enhance the combustion process. For an hydrogen engine emssion only water but in case of high engine load as rich mixture also NOX are emitted.(Liu et al., 2019)
Just like gasoline(petrol) engine hyrogen engine also works on 4 working stroke are
Suction : intake of air and fuel(in gaseous form) to engine . piston moves from TDC to BDC intake valves are opened, after its reaches in the BDC sudden close of intake valve by regulates with crank shaft.
Compression : In this stroke piston moves from BDC to TDC A/F mixture gets compressed to catch fire easily , spark plug will gave spark to engine to start combustion process will start, hydrogen engine are like petrol engine ,it cannot ignite itself by compression.
Expansion or working stroke : The piston again moves from TDC to BDC and valve remains closed combustion power (hydrogen molecule) give power to piston move downward .
Exhaust : piston moves from BDC to TDC at the mean time exhaust valve gets opened so combusted gases are emitted through its to tail pipe (cylencer) , generally hyrogen engine only emitts water.

Emission are $2H_2 + O_2 \rightarrow 2H_2O$

During high engine $H_2 + O_2 + N_2 \rightarrow H_2O + NO_X$

7. Adaption of existing engine :

Material for adapting exhisting engine are valve seats and hardened valve , connecting rods , non platinum tippedspark plug , higher voltage iginition coil , fuel injector are designed for gases instead of liquid , larger crank shaft damper ,modified intake manifold , stronger head gasket, positive pressure super charger and high temperature engine oil which approximately 1.5times higher in cost . Stochiometric air fuel ratio was about 34:1 . The maximum output 15% higher than gasoline . As such a datation in the existing engine hydrogen engine are bigger than gasoline engine.(Kakoee, Bakhshan, Motadayen, & Gharehghani, 2018)

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9 CONCLUSION:

This article gaves overall view of hydrogen production & storage , modification of engine which is competely benifical than gasoline engine and it is a next genration green engine. As in India, it is not a big issue to modify existing engines. To competein international market for petrolium very useful steps should be hydrogen engine , only inti al setup for hydrogen plant is pretty high cost. Still only one big research is reduction of NOX at high engine load. This may be overcome by introducing hydrogen based sensor which provides a consistent A/F mixture to engine in coming years. Hope fully next coming 10 years hydrogen engine will be seen in India.

Reference :

- Abe, J. O., Popoola, A. P. I., Ajenifuja, E., & Popoola, O. M. (2019). ScienceDirect Hydrogen energy , economy and storage : Review and recommendation. *International Journal of Hydrogen Energy*, *44*(29), 15072–15086. https://doi.org/10.1016/j.ijhydene.2019.04.068
- Alfaifi, B. Y., Ullah, H., Alfaifi, S., & Tahir, A. A. (2018). Photoelectrochemical solar water splitting : From basic principles to advanced devices, (February). https://doi.org/10.22261/FNAN.BDJOC3
- Bio-Derived Liquids to Hydrogen Distributed Reforming Working Group (BILIWG), Hydrogen Separation and Purification Working Group (PURIWG) & Hydrogen Production Technical Team Research Review 2007 Ann ual and Merit Review Reports. (2007).
- Carmo, M., & Fritz, D. L. (2013). A comprehensive review on PEM water electrolysis, *8*(1). https://doi.org/10.1016/j.ijhydene.2013.01.151
- Castro, N., Toledo, M., & Amador, G. (2019). diesel dual fuel compression ignition internal combustion engine. *Applied Thermal Engineering*. https://doi.org/10.1016/j.applthermaleng.2019.04.078
- Deheri, C., Acharya, S. K., Thatoi, D. N., & Mohanty, A. P. (2020). Review article A review on performance of biogas and hydrogen on diesel engine in dual fuel mode. *Fuel*, *260*(May 2019), 116337. https://doi.org/10.1016/j.fuel.2019.116337
- Hallenbeck, P. C., Sciences, L., States, U., Force, A., States, U., & Lazaro, C. Z. (2019). 3.10 Biohydrogen, *3*(October 2018), 128–139. https://doi.org/10.1016/B978-0-444-64046-8.00155-5
- Kakoee, A., Bakhshan, Y., Motadayen, S., & Gharehghani, A. (2018). An improvement of a lean burning condition of natural gas / diesel RCCI engine with a pre-chamber by using hydrogen. *Energy Conversion and Management*, *166*(February), 489–499.https://doi.org/10.1016/j.enconman.2018.04.063
- Kalamaras, C. M., & Efstathiou, A. M. (2013). Hydrogen Production Technologies : Current State and Future Developments, *2013*.
- Liu, Y., Wei, J., Lei, G., Chen, H., Lan, Y., Gao, X., & Wang, T. (2019). Spread of hydrogen vapor cloud during continuous liquid hydrogen spills. *Cryogenics*, *103*(June), 102975. https://doi.org/10.1016/j.cryogenics.2019.102975
- Rakopoulos, D. C., Rakopoulos, C. D., Giakoumis, E. G., & Dimaratos, A. M. (2020). Characteristics of performance and emissions in high-speed direct injection diesel engine fueled with diethyl ether / diesel fuel blends. *Energy*, *43*(1), 214–224. https://doi.org/10.1016/j.energy.2012.04.039
- Thesen, G., & Langhelle, O. (2009). Awareness , acceptability and attitudes towards hydrogen vehicles and filling stations : A Greater Stavanger case study and comparisons with London. *International Journal of Hydrogen Energy*, *33*(21), 5859–5867. https://doi.org/10.1016/j.ijhydene.2008.07.006
- Zhang, M., Lv, H., Kang, H., & Zhou, W. (2019). ScienceDirect A literature review of failure prediction and analysis methods for composite high-pressure hydrogen storage tanks. *International Journal of Hydrogen Energy*, (xxxx), 1–23. https://doi.org/10.1016/j.ijhydene.2019.08.001