International Journal For Technological Research In Engineering
Volume 7, Issue 9, May-2020 ISSN (Online): 2347 - 4718

FUTURE FUEL FOR GAS ENGINES – HYDROGEN

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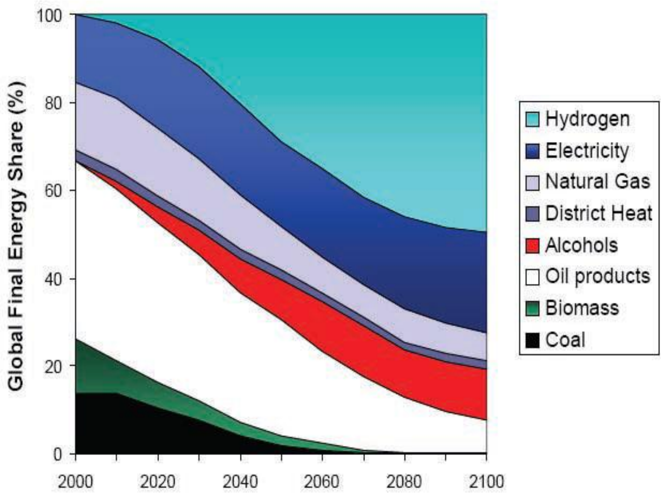
ABSTRACT: Hydrogen fuel is a zero-emission fuel burned with oxygen. It can be used in fuel cells or internal combustion engines. It has begun to be used in commercial fuel cell vehicles, such as passenger cars, and has been used in fuel cell buses for many years. It is also used as a fuel for spacecraft propulsion. Hydrogen is usually considered an energy carrier, like electricity, as it must be produced from a primary energy source such as solar energy, biomass, electricity (e.g. in the form of solar PV or via wind turbines), or hydrocarbons such as natural gas or coal. Conventional hydrogen production using natural gas induces significant environmental impacts; as with the use of any hydrocarbon, carbon dioxide is emitted. At the same time, the addition of 20% of hydrogen (an optimal share that does not affect gas pipes and appliances) to natural gas can reduce CO2 emissions caused by heating and cooking.

I. INTRODUCTION

Hydrogen can be considered as the simplest element in existence. Hydrogen is also one of the most abundant elements in the earth's crust. However, hydrogen as a gas is not found naturally on Earth and must be manufactured. This is because hydrogen gas is lighter than air and rises into the atmosphere as a result. Natural hydrogen is always associated with other elements in compound form such as water, coal and petroleum.

Hydrogen has the highest energy content of any common fuel by weight. On the other hand, hydrogen has the lowest energy content by volume. It is the lightest element, and it is a gas at normal temperature and pressure.



Above Figure evolution of global market shares of different final energy carriers for the period 1990-2100 based on the scenario by Barreto et al. [3]. The alcohols category includes methanol and ethanol.

II. WHAT MAKES HYDROGEN UNIQUE?

Hydrogen is an element that forms a diatomic molecule. Diatomic molecules are composed of two atoms of the same element and generally exist because the element is so reactive that it needs to bond to another atom. The reactivity of hydrogen contributes to many of its unique properties

Physical Properties of Hydrogen

The physical properties of hydrogen are the things that can be observed or measured, such as its density of 0.0000899 g/cm. The melting point of hydrogen is -259.2 C and the boiling point is -252.8 C. Hydrogen is a colorless gas that is so much lighter than air that it can actually escape the gravitational pull of the earth and shoot off into space. Hydrogen is also the first element on the periodic table and has only on proton and one electron. Hydrogen does not have any neutrons.

Some Chemical Properties of Hydrogen

Hydrogen is extremely combustible when in contact with oxygen. It is a non-metallic element, but behaves similarly to metals when in some bonding situations. Hydrogen is unique in that it can act like a metal in an ionic compound, donating electrons to the non-metal it bonds with or like a non-metal in a molecular compound, sharing electrons with another atom. Hydrogen has a relatively high electronegativity, which contributes to its affinity for bonding and to its diatomic nature.

Property	Hydrogen	Methane	Iso-octane
Molecular Weight (g/mol)	2.016	16.043	114.236
Density gaseous (kg/m3)	0.08	0.65	-
Density liquefied (kg/m3)	71	430-470	692
Minimum Ignition energy (mJ)	0.02	0.28	0.28
Minimum quenching distance (mm)	0.64	2.03	3.5
Lower heating value (MJ/kg)	120	50	44.3
Stoichiometric air/ fuel ratio (kg/kg)	34.2	17.1	15
Flammability limits in air (vol %)	4-75	5-15	1.1-6
Flammability limits (λ*)(-)	10-0.14	2-0.6	1.51-0.26
Flammability limits (φ1)(-)	0.1-7.1	0.5-1.67	0.66-3.85

Source: 1 Adapted from Verhelst, S. et. al. (2013), 2 Adapted from Gupta, R.B. (2009)

Table 1: Comparison of the fuel properties of hydrogen compared to methane andiso-octane.

III. HOW IS HYDROGEN PRODUCED?

Since hydrogen does not exist on Earth as a gas, it must be separated from other compounds. Two of the most common methods used for the production of hydrogen are electrolysis or water splitting and steam reforming.

Steam reforming is currently the least expensive method for producing hydrogen, but building the plants for the process is expensive. It is used in industries to separate hydrogen atoms from carbon atoms in methane. Unfortunately, because methane is a fossil fuel, the process of steam reforming

results in greenhouse gas emissions, which is linked to global warming.
The other method for the production of hydrogen is electrolysis. Electrolysis involves passing an electric current through water to separate water into its basic elements, hydrogen and oxygen. Hydrogen is then collected at the negatively charged cathode and oxygen at the positive anode. Hydrogen produced by electrolysis is extremely pure, and results in no emissions since electricity from renewable energy sources can be used.
Unfortunately, electrolysis is currently a very expensive process, but costs may fall if the cost of electricity to carry out the procedure also falls.
There are also several experimental methods of producing hydrogen such as photo-electrolysis and biomass gasification. Scientists have also discovered that some algae and bacteria produce hydrogen under certain conditions, using sunlight as their energy source.

IV. HYDROGEN PRODUCTION: BIOMASS GASIFICATION

Biomass gasification is a mature technology pathway that uses a controlled process involving heat, steam, and oxygen to convert biomass to hydrogen and other products, without combustion. Because growing biomass removes carbon dioxide from the atmosphere, the net carbon emissions of this method can be low, especially if coupled with carbon capture, utilization, and storage in the long term. Gasification plants for biofuels are being built and operated, and can provide best practices and lessons learned for hydrogen production. The U.S. Department of Energy anticipates that biomass gasification could be deployed in the near-term timeframe.

HOW DOES BIOMASS GASIFICATION WORK?
Gasification is a process that converts organic or fossil-based carbonaceous materials at high temperatures (>700°C), without combustion, with a controlled amount of oxygen and/or steam into carbon monoxide, hydrogen, and carbon dioxide. The carbon monoxide then reacts with water to form carbon dioxide and more hydrogen via a water-gas shift reaction. Absorbers or special membranes can separate the hydrogen from this gas stream.

Simplified example reaction
$C_6H_{12}O_6 + O_2 + H_2O \rightarrow CO + CO_2 + H_2$ + other species
Note: The above reaction uses glucose as a surrogate for cellulose. Actual biomass has highly variable composition and complexity with cellulose as one major component.

Water-gas shift reaction
$CO + H_2O \rightarrow CO_2 + H_2$ (+ small amount of heat)
Pyrolysis is the gasification of biomass in the absence of oxygen. In general, biomass does not gasify as easily as coal, and it produces other hydrocarbon compounds in the gas mixture exiting the gasifier; this is especially true when no oxygen is used. As a result, typically an extra step must be taken to reform these hydrocarbons with a catalyst to yield a clean syngas mixture of hydrogen, carbon monoxide, and carbon dioxide. Then, just as in the gasification process for hydrogen production, a shift reaction step (with steam) converts the carbon monoxide to carbon dioxide. The hydrogen produced is then separated and purified.

Component	**Wood Gas (%vol)**	**Charcoal(%vol)**
Nitrogen	**50-54**	**55-65**
Carbon	**17-22**	**28-32**
Carbon Dioxide	**9-15**	**1-3**
Hydrogen	**12-20**	**4-10**
Methane	**2-3**	**0-2**
Gas Heating Value(kJ/m3)	**5000-5900**	**4500-5600**

Table 2.Composition of gas from commercial wood and charcoal gasifiers(Wood=20%MC, Charcoal=7% MC).

V. METHODOLOGY

This review paper is made to understand the reason behind the hydrogen the future fuel. The basic information and data for this paper is taken by various secondary sources like online website, newspaper, various reports of SIAM, ICRA. An attempt is made here to understand the company ways of looking at both initiatives taken by the government to reduce the impact. The impact on Sales Volume, Revenue, Costs andProfit Margins for the FY 2016-17 iscarried out and inferences were drawn.

VI. LITERATURE OVERVIEW

In light of recent hydrocarbon shortage concerns, hydrogen is receiving increased attentionfrom the scientific community and the media for its potential role in a sustainable energy system.Hydrogen, like electricity, is an energy carrier and not an energy source, and significant researchis underway to test the feasibility of a future transition to a total hydrogen energy economy. Tounderstand the implications of such an economy, the Iowa Energy Center funded an extensiveliterature search over the summer of 2006. This search included approximately 130 researchreports, case studies, and other esteemed publications having to do with important aspects of thehydrogen economy (i.e. production, efficiency, electrochemical conversion, etc.). Findings ofthe search are focused on hydrogen production by electrolysis, several storage and delivery methods electrochemical conversion to electricity in fuel cells, and process efficiencies.
A direct result hydrogen will be An concoction vitality bearer (unlike electricity, which may be An present for electrons), it is conceivably that's only the tip of the iceberg successful Likewise a capacity medium over other innovations like batteries, particularly for utilize to renewable vitality frameworks for example, wind or sun based force. Hydrogen may be about inaccessibility over its atomic type for world. A number about handling techniques including electrolysis, steam transformation of regular gas, Furthermore coal gasification would the foci for broad creation research; Be that as electrolysis at present offers those best possibility to a manageable hydrogen economy. In light of hydrogen must to start with a chance to be handled

should "fuel" An hydrogen economy, inquiries need aid continuously raised over respect to if extensive scale incorporated handling offices or more diminutive confined generation focuses are additional positive position. Unified creation offices could transform vast amounts from claiming hydrogen a greater amount monetarily over more diminutive decentralized systems, Be that as long-separate appropriation of hydrogen of the offices that electrochemically change over hydrogen under power acquire included liability also brought down effectiveness.

VII. CONCLUSION

Hydrogen, a auxiliary vitality resource, is skilled of generating force and additionally fuel hotspot. Concerning illustration examined in this paper, it might be generated all the from an assortment about feedstock. However, over building hydrogen economy for the future, those dependability about hydrogen handling what's more it's in length expression impacts must be completely recognizedUnwavering quality might imply that's only the tip of the iceberg manageable hydrogen vitality inference hence transforming lesquerella outflows that could be hurtful of the surroundings. Today, the greater part built hydrogen processing will be from fossil fills through steam reforming procedure. Yet the constraint from claiming this elementary asset may be an looming crisis, hence, stronger R&D regions if make viewed as over handling H2 from renewable assets rather. Living and thermo substance process starting with biomass assets would rather savvy contrasted with electrolysis As far as its mechanical transformation parts. Biomass on the other hand, will be acknowledged likewise an flighty fuel feedstock needing homogeneity Furthermore conflicting nature helping to poor mechanical transformation innovations In those A long time. It will be still those vast majorities guaranteeing feedstock with gasification What's more pyrolysis concerning illustration the practically ideal heading adrift engineering for H2 commercialization. On understand this, there ought to a chance to be higher H2 yield starting with thermo concoction forms. Similarly as seen from those introduced courses a considerable measure for fill in still necessities with a chance to be done a standout amongst which may be moving forward the change advances through reforming In bring down temperatures, improve suitable of feedstock, Also expanding transformation effectiveness. Furthermore, to An All the more stable hydrogen creation the improvement of the budgetary Furthermore marketability of the fuel parts later on must be well made.

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