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Sustainable Production and Storage of Alternative Fuel as "Hydrogen"

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Abstract—*Use of hydrogen as an alternative fuel and energy carriers which offers potentially attractive advantages over existing energy sources. Hydrogen can be produced from natural gas by means of various chemical processes Steam reforming, partial oxidation, Auto thermal Reforming and Biomass Gasification etc. A Novel Method for the production of Hydrogen is Biomass Gasification which offers the earliest and economical route for the production of renewable hydrogen. By the application of catalyst called 'Dolomite' this process can be accelerated along with the simultaneous removal of continual buildup of condensable organic compounds present in producer gas. This paper emphasizes on minimization of storage cost and efficient production technique of hydrogen switching to environmentally more sustainable energy system along with the replacement of conventional fossil fuels from biomass. Compressed Hydrogen is more suitable storage technique over liquid hydrogen as a minimum environmental impact alternative because the energy associated with the liquefaction of hydrogen is much higher than associated with the generation of compressed hydrogen gas.*

Keywords: *Energy carriers, Biomass Gasification, Compressed Hydrogen, liquid hydrogen, Dolomite.*

1. INTRODUCTION

Energy-related issues, such as air pollution, global climate change, and energy supply security, raises the issue of future use of alternative fuels. Hydrogen offers large potential benefits in terms of reduced emissions of pollutants and greenhouse gases and diversified primary energy supply. No doubt, energy is one of the grand challenges facing the global community.

Hydrogen Economy has been gaining followers not only in the scientific and engineering areas but also in politics and businesses [1]

Iceland was one of the first pioneers in studying the feasibility and advantages of a hydrogen economy, announcing in 1999 its intention to become the world's first hydrogen society.[2] Hawaii and the South Pacific island of Vanuatu, have also promoted the hydrogen economy, whereas in China, the use of polygeneration using coal as a feedstock may become an economic source of hydrogen[3-4].

Hydrogen can be used with a high efficiency as a high

Quality energy carrier having practically no emission and can be produced using a variety of starting materials, both renewable and non-renewable sources.

Hydrogen possesses extremely high flammability property over a wide range of temperature and concentration. Moreover, it has a high combustion efficiency which is a property of a good fuel. The diffusion coefficient of hydrogen is 0.61 cm2/sec and it diffuses through air much more rapidly compared to other gaseous fuels and quick dispersion rate qualifies for safe operation [5].

H_2 has high energy content (lower heating value [LHV] of 33.3 kwh/kg), its volumetric energy density is considerably lower. At pressure of 680 atmospheres LHV of H_2 is about 1.32 kwh/L. The same number for liquid H_2 is 2.35 kwh/L in contact to this, corresponding energy density for Gasoline is 8.88 kwh/L [6-7].

In the past several studies have looked in to the cost, efficiency and environmental impact of the H_2 production, transportation and use. However most of these studies have only focused on the specific aspects of total supply [6-7].In this Paper we focused efficient production technique of Hydrogen by Biomass gasification with a Dolomite along……..

2. PRODUCTION OF HYDROGEN

There are several methods available for the production of hydrogen such as Steam Reforming, partial oxidation, Auto thermal Reforming, Biomass Gasification, and Electrolysis etc.

3. BIOMASS GASIFICATION USING A 'DOLOMITE' CATALYST

Biomass Gasification is a thermo chemical conversion of biomass into a combustible gas mixture (producer gas) through a partial combustion, this process involves some sort of inefficiencies due to continual build–up of long chain hydrocarbon called 'Tars' present in producer gas.

Therefore a catalyst called Dolomite is introduced in order to eliminate 'Tars'. Dolomite is a cheap, easily replaceable and most active catalyst if calcined and placed downstream of the gasifiers in a fluidized-bed of temperature above 800°C.

The products emanating from the gasification process chiefly comprise a mixture of the permanent gases CO, CO_2, H_2 and CH_4, Steam, char, tars, and ash.

The new synthetic gas needs to be cleaned from tars because it renders blockages and corrosion in down-stream process equipment. Furthermore it also blocked the active sites of catalyst by depositing on its surface.

Tar break down can be achieved possibly by two ways;

Either catalytic active methods can be used inside the reactor or filled with a bed of catalytic material. The tar decomposition reactions are mainly due to cracking, steam reforming, dry reforming etc.

To prevent losses in thermal efficiency a high temperature (1200°C to 1600°C) clean up stage is usually preferred. But for particle perspective temperature should be set at 700°C - 900°C. In this regard, Dolomite catalyst is used in down-stream of the gasifiers in a fluidized bed, which not only reduces tar up to a large extent but also increases yield.

Marco and Thomas [8], done experiment and reported that the minimization of the tar content in the product gas and optimization of the synthesis gas that can achieved by utilizing a tar cracking by Dolomite catalyst in a catalytic bed reactor.

Aznar et al. [9-10] also investigated the use of Malaga dolomite for steam/oxygen gasification. They reported that the H_2 content of the flue gas increased by 7 vol. %,

While the CO content decreased by 7 vol. %. This effect was due to a greater contribution of the water–gas shift[*] reaction as a result of a high steam content and high temperature.

[*] $CO + H_2O \rightarrow CO_2 + H_2$

4. HYDROGEN STORAGE

Present storage techniques for Hydrogen include compressed gas, cryogenic liquid and adsorption of solids. Compressed gas hydrogen storage is one of the environmentally and economically sustainable as well as viable technique.

Liquid hydrogen [LH_2] is not so economical because it has to be stored at (-) 253°C. Moreover liquefaction results in a loss of about 30-40 % of the energy content of liquid hydrogen and it is much higher than for compressed gas. Liquid hydrogen has major disadvantages, it is the boil off loss during dormancy, plus the fact that super insulated cryogenic containers are needed.

The capacity of the transport container is about 20 times higher for liquid hydrogen than for compressed gas.

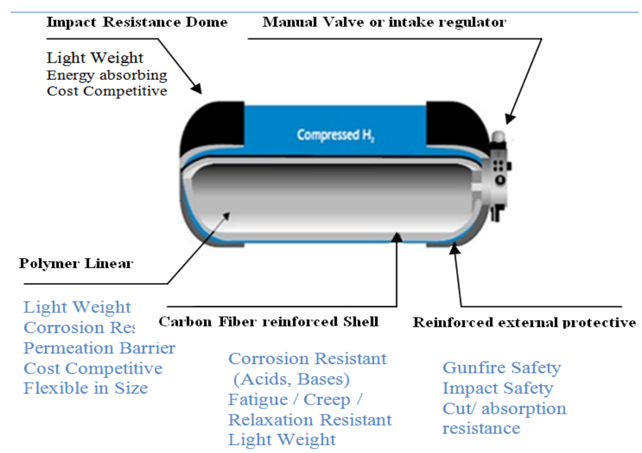
At 690 bar, 4.7 kg of hydrogen having 662 MJ energy can be stored in 60 gallon vessel compared to 5 gallon of storage volume of gasoline 14 kg having 662 MJ energy content.

Table 1: State-of-the-art technology and estimates for system volumes and weights for vehicular compressed gas and cryogenic liquid of 3 kg H_2

Technology	Volume [ltr]	Weight [kg]	Density [wt % H2]
35 MPa (350 bar) compressed H2	145	45	6.7
70 MPa (700 bar) compressed H2	100	50	6.0
Cryogenic liquid H2	90	40	7.5

Source: A. Niedzwiecki (QuantumTechnologies), US DOE Hydrogen Vision Meeting, November 2001 [11].

The most common and more novel method to store hydrogen in gaseous form is in steel light weight-composite tanks which can withstand high Pressures.



5. ENVIRONMENTAL SUSTAINABILITY

Nowadays, the energy related problem such as the energy security, air pollution and climate change, which question the sustainability of the current energy system. In this regard hydrogen economy would play a fundamental role in reducing worldwide CO_2 emissions, thus contribute to avoid global warming.

A co-product CO_2 produced along with hydrogen (H_2) in biomass gasification will have to be captured and stored in order to get significant reduction in net carbon releases and hence net decreases in environmental CO_2. Here, environmental sustainability analysis is restricted to the domain of hydrogen network only.

Gonzalo, Fernando and Ignacio experimentally proposed a Pareto Curve; they reported that the most promising alternative to achieve significant environmental savings without comprising too much the total cost of the network is to replace steam reforming by biomass gasification.

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7. CONCLUSION

In this research paper we addressed about the economic and efficient production of hydrogen by biomass gasification accelerated by a catalyst called Dolomite.

We also addressed that the produced hydrogen gas should be stored in compressed gaseous form rather than liquid. Although Liquid storage is less expensive relative to compressed storage. It is also found that the minimum environmental impact solution has more production plants than the minimum cost one (i.e. 50 vs. 36).

Compressed Hydrogen is more suitable storage technique over liquid hydrogen as a minimum environmental impact alternative because the energy associated with the liquefaction of hydrogen is much higher than associated with the generation of compressed hydrogen gas.

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