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STUDY AND PREPARATION OF HYDROGEN AS AN ALTERNATE FUEL IN VEHICLES

Bhutalapalli Sridivya [1], Ramavath Puramdas [2], SaiKrishna Kishore K [3], Venkata Ramesh Mamilla[4]

[2,3] Assitant Professor, [1,4] Associate Professor

DEPARTMENT OF MECHANICAL ENGINEERING

[1,2] Suprabhath College of Engineering & Technology, Ibrahimpatnam, Hyderabad

[3] Rao &Naidu Engineering College, Ongole.

[4] QIS College of Engineering &Technology, Ongole.

Abstract:

A hydrogen vehicle is an alternative fuel vehicle that uses hydrogen as its onboard fuel for motive power. The term may refer to a personal transportation vehicle, such as an automobile, or any other vehicle that uses hydrogen in a similar fashion, such as an aircraft. The power plants of such vehicles convert the chemical energy of hydrogen to mechanical energy either by burning hydrogen in an internal combustion engine, or by reacting hydrogen with oxygen in a fuel cell to run electric motors. Widespread use of hydrogen for fueling transportation is a key element of a proposed hydrogen economy

Hydrogen may be used as a transport fuel for internal combustion engine vehicles and fuel cell powered vehicles. Hydrogen may also be used to power turbines or in fuel cells for stationary power generation. In the future, hydrogen fuel cells may power most modes of transportation as well as lighting, heating and everyday electrical appliances in our homes and businesses

This paper deals with the preparation of hydrogen from Electrolysis method. The main objective of this paper is hydrogen gas is used in I.C engines. This paper also involves about the fuel cell Technology.

Key words: *Hydrogen, Electrolysis, Fuel cell*

Introduction

Hydrogen does not come as a pre-existing source of energy like fossil fuels, but is first produced and then stored as a carrier, much like a battery. Hydrogen for vehicle uses needs to be produced using either renewable or non-renewable energy sources. A suggested benefit of large-scale deployment of hydrogen vehicles is that it could lead to decreased emissions of greenhouse gases and ozone precursors. According to the United States Department of Energy "Producing hydrogen from natural gas does result in some greenhouse gas emissions. When compared to ICE vehicles using gasoline, however, fuel cell vehicles using hydrogen produced from natural gas reduce greenhouse gas emissions by 60%.While methods of hydrogen production that do not use fossil fuel would be more sustainable, currently renewable energy represents only a small percentage of energy generated, and power produced from renewable sources can be used in electric vehicles and for non-vehicle applications. The challenges facing the use of hydrogen in vehicles include production, storage,transportand distribution. The well-to-wheel efficiency for hydrogen, because of all these challenges will not exceed 25%.

Oil reserves around the world are diminishing, prices are rising, and environmental concern surrounding the use of fossil fuels is increasing. In order to move towards sustainability, To reduce the reliance on fossil fuels and find renewable forms of energy to power our homes, businesses, industries and transportation. Hydrogen, the most abundant element in the universe, holds the potential to be the backbone of a clean and sustainable energy system for our future. Hydrogen is an energy carrier that can be used in a myriad of different applications.

Today, Hydrogen is produced primarily from natural gas. However, Hydrogen can also be produced locally through entirely renewable means. Its use in fuel cells, an electrochemical energy conversion device, produces no harmful by-products (the only emission is pure water). In a world where national security is currently foremost in people's minds, and concern over environmental issues such as global warming and smog induced air pollution is increasing, hydrogen may present a bright future.

Oil companies, automobile industries, power utilities, and governments around the world are all starting to look towards hydrogen as the major energy carrier for the future. Most energy experts around the world believe that a transition from fossil fuels to a hydrogen economy is inevitable.

Need to go for Alternate Fuels

The entire surface transport of India is based on petroleum fuel, but its availability is of growing concern. The production of domestic crude has been declining and the transport system has been increasingly dependent on imported crude oil to meet its needs. There is a growing concern that the world may run out of petroleum based fuel resources. All these make it imperative that the search for alternative fuels is taken in right earnest. The alternative fuel we selected that takes the place of petroleum is hydrogen.

Hydrogen Fuel

Since the early 19th century, scientists have recognized hydrogen as a potential source of fuel. Current uses of hydrogen are in industrial processes, rocket fuel, and spacecraft propulsion. With further research and development, this fuel could also serve as an alternative source of energy for heating and lighting homes, generating electricity, and fueling motor vehicles. When produced from renewable resources and technologies, such as hydro, solar, and wind energy, hydrogen becomes a renewable fuel.

Composition of Hydrogen

Hydrogen is the simplest and most common element in the universe. It has the highest energy content per unit of weight—52,000 British Thermal Units (Btu) per pound (or 120.7 kilojoules per gram)—of any known fuel. Moreover, when cooled to a liquid state, this low weight fuel takes up 1/700 as much space as it does in its gaseous state. This is one reason hydrogen is used as a fuel for rocket and spacecraft propulsion, which requires fuel that is low weight, compact, and has a high energy content When burned (or combined) with pure oxygen, the only by products are heat and water. When burned (or combined) with air, which is about 68% nitrogen, some oxides of nitrogen (or NOx) are formed. Even then, burning hydrogen produces less air pollutants relative to fossilfuels.

METHODS FOR PRODUCING HYDROGEN

- Electrolysis Method
- Steam Electrolysis Method
- Photo Electrochemical Method

- Biological & Photo Biological
- Soluble metal complexes
- Semi-Conducting electrodes

PRODUCTION

The molecular hydrogen needed as an on-board fuel for hydrogen vehicles can be obtained through many thermochemical methods utilizing natural gas, coal (by a process known as coal gasification), liquefied petroleum gas, biomass (biomass gasification), by a process called thermolysis, or as a microbial waste product called biohydrogen or Biological hydrogen production. 95% of hydrogen is produced using natural gas, and 85% of hydrogen produced is used to remove sulfur from gasoline. Hydrogen can also be produced from water by electrolysis or by chemical reduction using chemical hydrides or aluminum. Current technologies for manufacturing hydrogen use energy in various forms, totaling between 25 and 50 percent of the higher heating value of the hydrogen fuel, used to produce, compress or liquefy, and transmit the hydrogen by pipeline or truck. Environmental consequences of the production of hydrogen from fossil energy resources include the emission of greenhouse gases, a consequence that would also result from the on-board reforming of methanol into hydrogen. Studies comparing the environmental consequences of hydrogen production and use in fuel-cell vehicles to the refining of petroleum and combustion in conventional automobile engines find a net reduction of ozone and greenhouse gases in favor of hydrogen. Hydrogen production using renewable energy resources would not create such emissions or, in the case of biomass, would create near-zero net emissions assuming new biomass is grown in place of that converted to hydrogen. However the same land could be used to create Biodiesel, usable with (at most) minor alterations to existing well developed and relatively efficient diesel engines. In either case, the scale of renewable energy production today is small and would need to be greatly expanded to be used in producing hydrogen for a significant part of transportation needs. As of December 2008, less than 3 percent of U.S. Electricity was produced from renewable sources, not including dams. In a few countries, renewable sources are being used more widely to produce energy and hydrogen. For example, Iceland is using geothermal power to produce hydrogen, and Denmark is using wind.

Producing of Hydrogen from electrolysis method

Although it is the most abundant element in the universe, hydrogen is not found in elemental form and must be produced or reformed from a primary source. Today, hydrogen is primarily produced through reformation of natural gas, electrolysis of water, or partial oxidation of heavy fossil fuels such as diesel. Close to 98% of hydrogen is presently generated from fossil fuels.14 Steam reforming of natural gas is currently the most widely used and economical method of producing hydrogen.15 Steam reforming of natural gas involves the high temperature (769-925 degrees Celsius) catalytic conversion of methane and water to produce carbon dioxide and Hydrogen.16 A large-scale methane reformer can attain fuel conversion efficiencies of up to 83%.

Hydrogen bound in organic matter and in water makes up 70% of the earth's surface. Breaking up these bonds in water allows us produce hydrogen and then to use it as a fuel. There are numerous processes that can be used to break these bonds. Described below are a few methods for producing hydrogen that are currently used, or are under research and development.

Most of the hydrogen now produced in the United States is on an industrial scale by the process of steam reforming, or as a byproduct of petroleum refining and chemicals production. Steam reforming uses thermal energy to separate hydrogen from the carbon components in methane and methanol, and involves the reaction of these fuels with steam on catalytic surfaces. The first step of the reaction decomposes the fuel into hydrogen and carbon monoxide. Then a "shift reaction" changes the carbon monoxide and water to carbon dioxide and hydrogen. These reactions occur at temperatures of 392° F (200 ° C) or greater.

Electrolysis separates the elements of water—H and oxygen (O)—by charging water with an electrical current. Adding an electrolyte such as salt improves the conductivity of the water and increases the efficiency of the process. The charge breaks the chemical bond between the hydrogen and oxygen and splits apart the atomic components, creating charged particles called ions. The ions form at two poles: the anode, which is positively charged, and the cathode, which is negatively charged.

Storage

Hydrogen has a very low volumetric energy density at ambient conditions, equal to about one-third that of methane. Even when the fuel is stored as liquid hydrogen in a cryogenic tank or in a compressed hydrogen storage tank, the volumetric energy density (megajoules per liter) is small relative to that of gasoline. Hydrogen has a three times higher energy density by mass compared to gasoline (143 MJ/kg versus 46.9 MJ/kg). Some research has been done into using special crystalline materials to store hydrogen at greater densities and at lower pressures. A recent study by Dutch researcher Robin Gremaud has shown that metal hydride hydrogen tanks are actually 40 to 60-percent lighter than an equivalent energy battery pack on an electric vehicle permitting greater range for H2 cars.

Potential Uses for Hydrogen

Hydrogen has actually been used in the transportation, industrial, and residential sectors in the United States for many years. Many people in the late 19th century burned a fuel called "TOWN GAS" which is a mixture of hydrogen and carbon monoxide. Several countries, including Brazil and Germany, still distribute this fuel. Hydrogen was used in early "hot-air" balloons, and later in airships (dirigibles) during the early 1900's.

The Space Shuttle uses hydrogen as fuel for its rockets. Automobile manufacturers have developed hydrogen-powered cars.

Benefits of Hydrogen as fuel

- Strengthen National Energy Security
- Reduce Greenhouse Gas Emissions
- Improve Energy Efficiency
- Reduce Air Pollution

Hydrogen gas for IC engines

Burning hydrogen creates less air pollution than gasoline or diesel. Hydrogen also has a higher flame speed, wider flammability limits, higher detonation temperature, burns hotter, and takes less energy to ignite than gasoline. This means that hydrogen burns faster, but carries the danger of pre-ignition and flashback. While hydrogen has its advantages as a vehicle fuel it still has a long way to go before it can be used as a substitute for gasoline.

Hydrogen gas (H2) is being explored for use in combustion engines and fuel-cell electric vehicles. It is a gas at normal temperatures and pressures, which presents greater transportation and storage hurdles than exist for the liquid fuels. Storage systems being developed include compressed hydrogen, liquid hydrogen, and chemical bonding between hydrogen and a storage material (for example, metal hydrides). While no transportation distribution system currently exists, for hydrogen transportation use, the ability to create the fuel from a variety of resources and its clean-burning properties make it a desirable alternative fuel.

Increasing pollution from cars and airplanes has created smog clouds across the country. Hydrogen, on the other hand, emits no toxins, and is also clean and efficient. The hydrogen ICE is a common-sense power plant that uses existing, proven technologies to deliver the environmental benefits of a hydrogen fuel cell, but at a fraction of the complexity and cost.

Because hydrogen has a very wide combustion range (from 4 to 75 percent), hydrogen-fueled engines are able to use a wider range of air/fuel mixtures than gasoline engines, and can be run in the fuel-efficient "lean" regime without the complications of pre-ignition or "knock." It can reach an overall efficiency of 38 percent, which is approximately 25 percent better than a gasoline engine.

And, because there are no carbon atoms in the fuel, combustion of hydrogen produces no hydrocarbon or carbon dioxide emissions. Even without after treatment, oxides of nitrogen are very low, and catalyst research may soon reduce tailpipe output of potentially smog-forming emissions to below ambient conditions in many cities.

Fuel cell Technology

Fuel cells are electrochemical energy conversion devices, which convert chemical energy in the form of hydrogen and oxygen into an electrical current and the byproduct of water (H2 + 1/2O2 ┼H2O). Fuel cells may be used in both transportation applications and stationary applications. Compared to electricity generation from coal or gas, hydrogen fuel cells are extremely efficient.

The fuel cell is also two to three times more efficient in converting fuel to power than internal combustion engine vehicle Heat engines, such as internal combustion engines or gas turbines, use heat energy to produce mechanical energy. Therefore efficiencies are constrained by the Carnot Limit.

Carnot Efficiency = $(T_H - T_L) / T_H$

Where, T_H = absolute high temperature (temperature of heat source)

T_L = absolute low temperature (temperature of sink to which waste heat is rejected)

The theoretical efficiency of the fuel cell is related to the ratio of the chemical free energy of Gibbs free energy and the total heat energy or Enthalpy of the fuel.

So, Fuel Cell Efficiency = $\Delta G^{o} / \Delta H^{o}$

Types of fuel cells

There are a number of different types of fuel cells, including Polymer Electrolyte fuel cells, Phosphoric Acid fuel cells, alkaline fuel cells, and Solid Oxide fuel cells. Classified by the electrolyte used, each has various advantages and disadvantages relating to cost, temperature, fuel purity, size and lifetime. All the above fuel cells can use hydrogen as a fuel; however, some of the high temperature fuel cells (Molten Carbonate and Solid Oxide fuel cells) may also run on other hydrogen-rich fuels such as methane.

1) Polymer electrolyte fuel cells are being trailed in a number of hydrogen fuel cell vehicles around the world. They also have the potential to be used for residential and small commercial distributed power generation, for premium power generation (applications where power supply must either be uninterruptible or particularly clean) and telecommunications.
2) Alkaline fuel cells are currently used for power generation during space flights and have potential to be used in utility vehicles (for example military applications) and small watercraft. Phosphoric acid fuel cells may be used for base load power and cogeneration. Cogeneration is where waste heat from the fuel cell is also utilized.

3) Molten carbonate fuel cells and solid oxide fuel cells generally use synthetic gas and methane as primary fuels and are most suited to the production of base load power, for cogeneration applications and hybrid power. While hydrogen fuel cells are the most advanced, other types of fuel cells, such as direct methanol fuel cells and metal air fuel cells are being developed.
4) Direct methanol fuel cells may be used in electric motor vehicles or portable power sources in lap top computers or mobile phones. Metal-air fuel cells, may be used in the future as portable power sources or in transportation. Metal-air fuel cells are yet to be developed to a commercial standard.

Benefits and Disadvantages of hydrogen fuel cells:

- Increasing efficiency at low loads
- Low maintenance(due to few moving parts)
- Low noise
- Poor availability
- High initial investment
- Lack of supporting infrastructure

Many companies are currently researching the feasibility of building hydrogen cars, and some automobile manufacturers have begun developing hydrogen cars (see list of fuel cell vehicles). Funding has come from both private and government sources. However, the Ford Motor Company has dropped its plans to develop hydrogen cars, stating that "The next major step in Ford's plan is to increase over time the volume of electrified vehicles". Similarly, French Renault-Nissan announced in 2009 that it is cancelling its hydrogen car R&D efforts. As of October 2009, General Motors CEO Fritz Henderson noted that GM had reduced its hydrogen program because the cost of building hydrogen cars was too high. "It's still a ways away from commercialization", he said. The "Volt will likely cost around $40,000 while a hydrogen vehicle would cost around $400,000. Most hydrogen cars are currently only available as demonstration models for lease in limited numbers and are not yet ready for general public use. The estimated number of hydrogen-powered cars in the United States was 200 as of October 2009, mostly in California. Honda introduced its fuel cell vehicle in 1999 called the FCX and have since then introduced the second generation FCX Clarity. In 2007 at the Greater Los Angeles Auto Show, Honda unveiled the first production model of the FCX Clarity. Limited marketing of the FCX Clarity began in June 2008 in the United States, and it was introduced in Japan in November 2008. The FCX Clarity is available in the U.S. only in Los Angeles Area, where 16 hydrogen filling stations are available, and as of July 2009, 10 drivers had leased the Clarity for US$600 a month. Honda stated that it could start mass producing vehicles based on the FCX concept by the year 2020 and reaffirmed, in 2009, that it continues to put resources into hydrogen fuel cell development, which it sees as "a better long term bet than batteries and plug-in vehicles".

In 2008, Hyundai announced its intention to produce 500 FC vehicles by 2010 and to start mass production of its FC vehicles in 2012. In early 2009, Daimler announced plans to begin its FC vehicle production in 2009 with the aim of 100,000 vehicles in 2012-2013. In 2009, Nissan started testing a new FC vehicle in Japan.

In September 2009, Daimler, Ford, General Motors, Honda, Hyundai, Kia, Renault, Nissan and Toyota issued a joint statement about their undertaking to further develop and launch fuel-cell electric vehicles as early as 2015.

In February 2010 Lotus Cars announced that it was developing a fleet of hydrogen taxis in London, with the hope of them being ready to trial by the 2012 Olympic Games. London's deputy mayor, Kit Malthouse, said he hoped six filling stations would be available and that around 20-50 taxis would be in operation by then, as well as 150 hydrogen-powered buses.

In March 2010, General Motors said it had not abandoned the fuel-cell technology and still targeted to introduce hydrogen vehicles to retail customers by 2015. Charles Freese, GM's executive director of global powertrain engineering, stated that the company believes that both fuel-cell vehicles and battery electric vehicles are needed for reduction of greenhouse gases and reliance on oil, and the U.S. should follow Germany and Japan in adopting a more uniform strategy on advanced technology options. Both have announced plans to open 1,000 hydrogen fuel stations.

CONCLUSIONS

To maintain economic prosperity and quality of life, that meets the conflicting demands for increased supply, increased energy security, whilst maintaining cost competitiveness, reducing climate change and improving air quality. Hydrogen and fuel cells are firmly established as strategic technologies to meet these objectives. They can create win-

win situations for public and private stakeholders alike. The benefits will only start to really flow after public incentives and private effort is applied to stimulate and develop the main markets - stationary power and transport. This should be done in a balanced way that reflects the most cost-effective use of the various alternative primary energy sources and energy carriers.

References

"Emissions Control with Lean Operation Using Hydrogen-Supplemented Fuel", R. F. Stebar, and F. B. Parks.

"A Two-Charge Engine Concept Hydrogen Enrichment", J. Houseman and F. Hoehn.

"Technical Comparison Between Hythane, CNG and Gasoline Fueled Vehicles", Report by Energy Task Force of the Urban Consortium, City and County of Denver, Alternative Fuels Unit.

"A Study of Hydrogen/Methane Combustion in Spark Ignition Engine", J. Fulton, F. Lynch, B. Wilson, J. Schneider, and J. Yost, Proceedings of the Annual Automotive Technology Development Contractors' Coordination Meeting, Dearborn, Michigan,

"Advanced Hydrogen/Methane Utilization Technology Demonstration- Final Report", F. Lynch and J. Fulton

"Hythane- An Ultraclean Transportation Fuel", V. Raman, J. Hansel, J. Fulton, F. Lynch, and D. Bruderly,