International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-5 Issue-4, April 2016

Hydrogen Fuel Cell in Automobile

Rushinesh Bagal, Kaushik Deshpande, Digvijay Yadav

Abstract*— one of the most dynamic fields which have been developing rapidly with time is automobile. It has been observed that even today after so much of advancement automobile makers are striving hard to make it a perfect machine in every aspect, enabling it to face any problems that would come up in future, and one such biggest problem is the depletion of fossil fuels which forces us to look for alternate and equally efficient fuels. This paper is based on a study done in this direction. Hydrogen is not an energy source, it is an energy carrier. It can store and deliver energy but still, must be produced from compounds that contain it. Hydrogen can be produced using diverse, domestic resources including fossil fuels, such as coal (with carbon sequestration) and natural gas; nuclear; and biomass("Hydrogen Production.") Hydrogen fuel cells convert the energy in hydrogen to electricity. They are much more efficient at converting the energy source than other methods. Hydrogen fuel cell vehicles use electric motors and are much more energy efficient. They use 40-60 percent of the fuel's energy. This would correspond to more than a 50% reduction in fuel consumption when compared to a conventional vehicle with an internal combustion engine. Fuel cells are also much quieter, have fewer moving parts, and are well suited to a variety of applications. This paper is based on "HYDROGEN FUEL CELL".A Fuel Cell is an electrochemical device that combines hydrogen and oxygen to produce electricity, with heat as its by-product. Firstly we understand the main concept of fuel cell. Then working, the need for having an alternate fuel. Next we see how the fuel technology can be used. Then we see the advantages of the fuel cells by understanding their detailed composition and functioning. Then the efficiency of fuel cell. And then challenges to fuel cell.

***Index Terms*— Energy, Fuel cell, Hyrogen application, Environmental benefits, Environment, Sustainable development.**

I. INTRODUCTION

"An old idea whose time has come". Fuel cells invented in 1838 by Swiss scientist Christian Friedrich [7]. A Fuel Cell is an electrochemical device that combines hydrogen and oxygen to produce electricity, with water and heat as its by-product [6].Since conversion of the fuel to energy takes place via an electrochemical process, not combustion .It is a clean, quiet and highly efficient process- two to three times more efficient than fuel burning. The topic of alternative fuel vehicles is especially relevant given the events of the last few weeks [6,7]. As gas prices continue to rise this summer we'll likely see this topic get more and more attention. It operates similarly to a battery, but it does not run down nor does it require recharging. As long as fuel is supplied, a Fuel Cell will produce both energy and heat.

Manuscript published on 30 April 2016.
***** Correspondence Author (s)
Rushinesh Sayajirao Bagal*, BE Mechanical Engineering, PVPIT Pune, SP Pune University, Pune, India.
Kaushik Nitin Deshpande, BE Mechanical Engineering, PVPIT Pune, SP Pune University, Pune, India.
Digvijay Ashok Yadav BE Mechanical Engineering, PVPIT Pune, SP Pune University, Pune, India.

II. CONSTRUCTION AND WORKING

It operates similarly to a battery, but it does not run down nor does it require recharging. As long as fuel is supplied, a Fuel Cell will produce both energy and heat. A Fuel Cell consists of two catalyst coated electrodes surrounding an electrolyte. One electrode is an anode and the other is a cathode. The process begins when Hydrogen molecules enter the anode [1]. The catalyst coating separates hydrogen's negatively charged electrons from the positively charged protons. The electrolyte allows the protons to pass through to the cathode, but not the electrons. Instead the electrons are directed through an external circuit which creates electrical current [8]. While the electrons pass through the external circuit, oxygen molecules pass through the cathode. There the oxygen and the protons combine with the electrons after they have passed through the external circuit. When the oxygen and the protons combine with the electrons it produces water and heat. Individual fuel cells can then be placed in a series to form a fuel cell stack. The stack can be used in a system to power a vehicle or to provide stationary power to a building [4].

Proton Exchange Membrane (PEM)

This is the leading cell type for passenger car application. Uses a polymer membrane as the electrolyte. Operates at a relatively low temperature, about 175 degrees. Has a high power density, can vary its output quickly and is suited for applications where quick start up is required making it popular for automobiles [2,3]. Sensitive to fuel impurities.

Hydrogen Production

Electrolytic processes use an electric current to split water into hydrogen and oxygen.

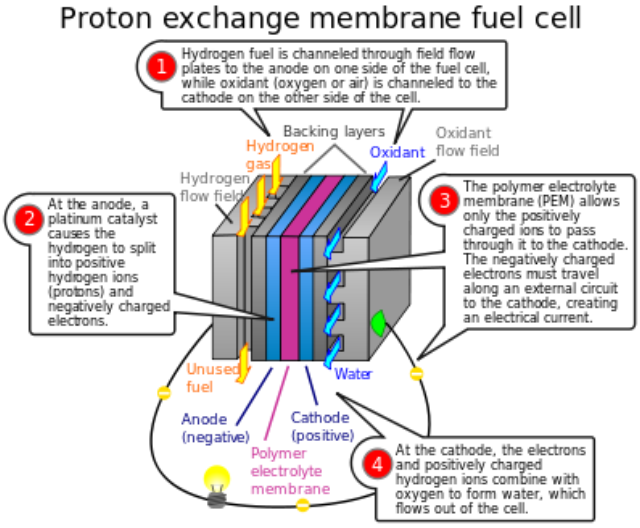

Fig.(1). Proton Exchange Membrane [9]

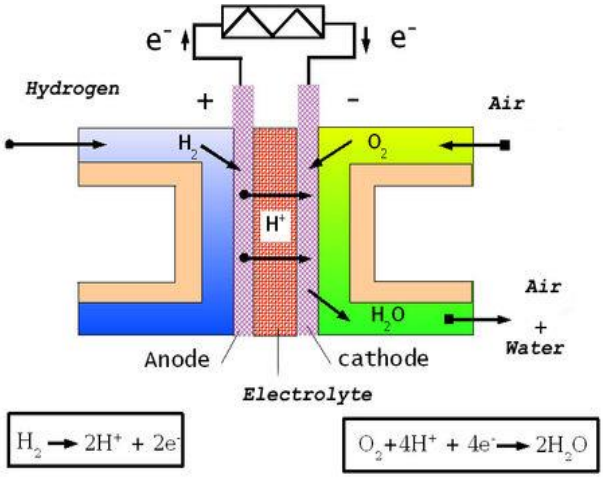

Fig.(2). Chemical Reaction [6]

III. STORAGE OF HYDROGEN

Developing safe, reliable, compact and cost-effective hydrogen storage is one of the biggest challenges to widespread use of fuel cell technology. Hydrogen has physical characteristics that make it difficult to store large quantities without taking up a great deal of space [1]. Hydrogen will need to be stored on board vehicles, at hydrogen production sites, refuelling stations and stationary power sites. Hydrogen has a very high energy content by weight (3x more than gasoline) and a very low energy content by volume (4x less than gasoline). If the hydrogen is compressed and stored at room temperature under moderate pressure, too large a fuel tank would be required. Researchers are trying to find light-weight, safe [3], composite materials that can help reduce the weight and volume of compressed gas storage systems. Liquid hydrogen could be kept in a smaller tank than gaseous hydrogen, but liquefying hydrogen is complicated and not energy efficient. Liquid hydrogen is also extremely sensitive to heat and expands significantly when warmed by even a few degrees, thus the tank insulation required affects the weight and volume that can be stored [4]. If the hydrogen is compressed and cryogenically frozen it will take up a very small amount of space requiring a smaller tank, but it must be kept super cold- around -120 to -196 degrees Celsius. Using current storage technology, in order to place a sufficient amount of hydrogen onboard a vehicle to provide 300-mile driving range the tank would be larger than the trunk of a typical automobile. This large of a tank would add to the overall weight of the car and reduce fuel economy [4].

IV. FUELLING SYSTEM

There were over 85 hydrogen refueling stations in the U.S. in 2010. As of June 2012 California had 23 hydrogen refueling stations in operation. Honda announced plans in March 2011 to open the first station that would generate hydrogen through solar-powered renewable electrolysis. South Carolina also has two hydrogen fuelling stations, in Aiken and Columbia, SC [1, 3]. The University of South Carolina, a founding member of the South Carolina Hydrogen & Fuel Cell Alliance, received 12.5 million dollars from the United States Department of Energy for its Future Fuels Program [5]. The first public hydrogen refuelling station in Iceland was opened in Reykjavík in 2003. This station serves three buses built by DaimlerChrysler that are in service in the public transport net of Reykjavík. The station produces the hydrogen it needs by itself, with an electrolyzing unit (produced by Norsk Hydro), and does not need refilling: all that enters is electricity and water. Royal Dutch Shell is also a partner in the project. The station has no roof, in order to allow any leaked hydrogen to escape to the atmosphere [4]. The current 14 stations nationwide in Germany are planned to be expanded to 50 by 2015 through its partnership Now GMBH. Japan also has a hydrogen highway, as part of the Japan hydrogen fuel cell project. Twelve stations have been built in 11 cities in Japan, and additional hydrogen stations could potentially be operational by 2015. Canada, Sweden and Norway also have hydrogen highways being implemented [4].

V. EFFICIENCY

- Because no fuel is burned to make energy, fuel cells are fundamentally more efficient than combustion systems.
- Additionally when the heat comes off of the fuel cell system it can be captured for beneficial purposes.
- This is called Cogeneration.
- The gasoline engine in a conventional car is less than 20% efficient in converting the chemical energy in gasoline into power.
- Fuel Cell motors are much more efficient and use 40-60% of the hydrogen's energy.
- Fuel Cell cars would lead to a 50% reduction in fuel consumption.
- Fuel Cell vehicles can be up to 3 times more efficient than internal combustion engines.
- Fuel Cell power generation systems in operation today achieve 40% to 50% fuel-to-electricity efficiency.
- In combination with a turbine, electrical efficiencies can exceed 60%.
- When Cogeneration is used, fuel utilization can exceed 85%.

VI. ADVANTAGES

Environmental Benefits

- Fuels cells can reduce air pollution today and offer the possibility of eliminating pollution in the future.
- A fuel cell power plant may create less than one ounce of pollution per 1,000 kilowatt-hours of electricity produced.
- Conventional combustion generating systems produce 25 pounds of pollutants for the same electricity.
- Fuel Cell Vehicles with hydrogen stored on-board produce ZERO POLLUTION in the conventional sense.
- The only by products of these Fuel Cell vehicles are water and heat.
- Fuel Cell Vehicles with a reformer on board to convert a liquid fuel to hydrogen would produce a small amount of pollutants, but it would be 90% less than the pollutants produced from combustion engines.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Other Benefits

- The fuel economy is in between 50-60 miles/kg.
- It also works in temperature between -35 to 50 degree Celsius.
- It's maintains is as low as compare to combustion engine.
- It would lead to a 50% reduction in fuel consumption
- Fuel Cell motors are much more efficient and use 40-60% of the hydrogen's energy.
- No dissipation of hazardous gases i.e. totally eco-friendly.

VII. DISADVANTAGES

Environmental

- Hydrogen is explosive when it comes in contact with environment.
- So we need to proper storage of hydrogen.

Cost

- The cost of fuel cells must be reduced to compete with conventional technologies
- Conventional internal combustion engines cost $25-$35/kW; a fuel cell system would need to cost $30/kW to be competitive

System Size

- The size and weight of current fuel cell systems must be reduced to attain market acceptance, especially with automobiles.

Durability and Reliability

- Durability of fuel cell systems have not yet been adequately established
- The durability standard for automobiles is approximately 150,000 miles and the ability to function under normal vehicle operating conditions.
- For stationary systems 40,000 hours of reliable operation in a temperature range of -35 degree Celsius to 40 degrees Celsius will be required for market acceptance.

VIII. APPLICATIONS

Transportation

- All major automakers are working to commercialize a fuel cell car.
- Automakers and experts speculate that a fuel cell vehicle will be commercialized by 2010.
- 50 fuel cell buses are currently in use in North and South America, Europe, Asia and Australia.
- Trains, planes, boats, scooters, forklifts and even bicycles are utilizing fuel cell technology as well.

Stationary Power Stations

- Over 2,500 fuel cell systems have been installed all over the world in hospitals, nursing homes, hotels, office buildings, schools and utility power plants
- Most of these systems are either connected to the electric grid to provide supplemental power and backup assurance or as a grid-independent generator for locations that are inaccessible by power lines

Micro Power

- Consumer electronics could gain drastically longer battery power with Fuel Cell technology
- Cell phones can be powered for 30 days without recharging
- Laptops can be powered for 20 hours without recharging.

Military Applications

- Fuel Cell technology in the military can help save lives because it reduces tell-tale heat and noise in combustion.
- Handheld battlefield computers can be powered for 10 times longer with Fuel Cell power meaning soldiers could rely on their computers in the field for longer periods of time.

IX. CONCLUSION

It focuses towards the sustainable development which requires solving environmental problems. These problems cover a continuously growing range of air pollution, eco system degradation and extend over ever-wider areas. Energy resources such as solar, wind, hydro, and biomass are generally considered renewable and therefore sustainable over the relatively long term. The use of these sources in hydrogen production will be a key factor in sustainable development. It also helps to attain or try to attain sustainable development to developing hydrogen and fuel cell technologies.

REFERANCES

1. EIA (Energy Information Administration). (2005). Official energy statistics from the U.S. Government. Via http://tonto.eia.doe.gov/steo_query/app/pricepage.htm.
2. Conte, M., Iacobazzi, A., Ronchetti, M., Vellone, R "Hydrogen economy for a sustainable development: state-ofthe-art and technological perspectives". Journal of Power,Sources, Vol.100, 001, 171-187.
3. Hopwood, B. Mellor, M. and O'Brien, G. "Sustainable development: mapping different approaches". Sustainable Development, Vol. 13, 2005, 38–52.
4. Jordan Journal of Mechanical and Industrial Engineering, Hydrogen and Fuel Cell Technologies for Sustainable Future, Ibrahim Dincer, Faculty of Engineering & Applied Science, University of Ontario Institute of Technology, North Oshawa, Canada. Volume 2, Number 1, Mar. 2008, ISSN 1995-6665.
5. AE (Automotive Engineering). (1996). "Life cycle analysis: getting the total picture on vehicle engineering alternatives",March 1996, 49-52.
6. www.fuelcelltoday.com/history
7. www.altenergy.org/renewables/fuel_cells_history.html
8. Book- Hydrogen and Fuel cells (second edition)
9. Wikipedia (Diagram)

Rushinesh Sayajirao Bagal BE Mechanical final year, Member of SAE India, Indian Patent "Automatic speed control of horizontal axis wind turbine by using spiral spring" (status- Published). National level paper presentation winner.

Kaushik Nitin Deshpande. BE Mechanical final year, Member of SAE India.

Digvijay Ashok Yadav. BE Mechanical final year, Member of SAE India,