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A REVIEW ON HYDROGEN: THE FUTUREFUEL

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ABSTRACT

Present paper deals with the use of hydrogen as fuel and with its future aspects too. Due to increase in dependency in non-renewable energy resources, there has been studies and interest in using a cleaner and more eco-friendly approach to consuming energy and one such approach is hydrogen fuel, combination of oxygen from air and water through electricity produces hydrogen fuel cell. Hydrogen can be produced by variety of technologies, such as chemical, biologic, electrolytic, and photolytic. Hydrogen can be produced from methods like gasification, electrolysis, and hydrogen fuel cells etc. Hydrogen fuel cells functions best with the help of proton exchange membranes fuel cells (PEMFC). PEMFC is type of fuel cell being developed mainly for transport applications, as well as for stationary fuel cell application. Their distinguishing features include lower temperature/ pressure ranges (50 to 100 C) and a special proton conducting polymer electrolyte membrane. The major application of polymer electrolyte membrane fuel cells focuses on transportation primarily because of their potential impact on the environment e.g. the control of emission of the greenhouse gases.

KEYWORDS: Hydrogen, Fuel Cells, PEMFC.

INTRODUCTION

For many years, the focus of the emerging "hydrogen economy" has been on the use of hydrogen fuel cells for vehicles. While federal and state government and automakers still continue to invest in and promote policies to create the "hydrogen highway," private businesses and government agencies are increasingly deploying fuel cells for stationary power applications. Stationary fuel cells are a technology that is commercially available, reliable, suitable to a wide variety of applications, declining in costs, and with federal and state support, becoming more affordable [8]. Due to the increase in dependency in non-renewable energy resources, there has been studies and interest in using a cleaner and more eco-friendly approach to consuming energy. Although there is not yet a current shortage of conventional fuels, such as reserves of coal, oil, and natural gas, they provide hazardous gases

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that helps in polluting our world even further not only that but also helps in the expansion of the earth ozone layer that protects our earth from UV rays. Therefore, research is conducted to provide a sustainable environment for future generations [5, 9].

Hydrogen has several benefits as a fuel for vehicles compared to petroleum. A hydrogen fuel cell does not generate any pollution. The only by-product is pure water, which leaves the system as both liquid and vapour. The amount of water produced by a fuel cell propulsion system in a typical driving schedule is comparable to the amount of water produced by an internal combustion engine. If another fuel is used (such as methanol or gasoline) and reformed on board, the propulsion system has some emissions generated in the reforming process, but those emissions are in general still much lower than the emissions from an internal combustion engine and would typically qualify it for ultra-low emission vehicles [1, 2, 11]

Hydrogen is being used as fuel in increasing numbers of today's motor vehicles which are expanding locally and internationally, with the goal to reduce carbon dioxide emissions [5, 16, and 17]. The National Aeronautics and Space Agency (NASA) have been using hydrogen as fuel in their space shuttles since the 1950's [5].

Finding Hydrogenis not an easy task because it doesn’t found freely in nature .We can modify them by fossil fuel or by natural gases. This aspect indicates that hydrogen is like with the usage of electricity. The combination of oxygen from the air and water through electricity produce Hydrogen fuel cell. The usage of Hydrogen and fuel cell technologies will affect significant social, economic and environmental which will impact [10]. Hydrogen can be produced from a variety of feed stocks. These include fossil resources, such as natural gas and coal, as well as renewable resources, such as biomass and water with input from renewable energy sources (e.g. Sunlight, wind, wave or hydro-power). A variety of process technologies can be used, including chemical, biological, electrolytic, photolytic and thermo-chemical. Each technology is in a different stage of development, and each offers unique opportunities, benefits and challenges. Local availability of feedstock, the maturity of the technology, market applications and demand, policy issues, and costs will all influence the choice and timing of the various options for hydrogen production [13].

Enough electricity can be produced to power electric vehicles. The usage of Hydrogen and fuel cell technologies will affect significant social, economic and environmental which will impact [10]. Hydrogen can be produced from a variety of feed stocks. These include fossil resources, such as natural gas and coal, as well as renewable resources, such as biomass and water with input from renewable energy sources (e.g. Sunlight, wind, wave or hydro-power). A variety of process technologies can be used, including chemical, biological, electrolytic, photolytic and thermo-chemical. Each technology is in a different stage of development, and each offers unique opportunities, benefits and challenges. Local availability of feedstock, the maturity of the technology, market applications and demand, policy issues, and costs will all influence the choice and timing of the various options for hydrogen production [13].

Investments in hydrogen fuel cells have improved significant technologies, but have also revealed the many difficulties of designing fuel cell and hydrogen storage and dispensing systems that are practical, cost-effective, and safe to operate. In this context, it is worth noting that hydrogen can also be so much effective apart from fuel cells as a fuel for combustion engines and gas turbines in a variety of transport as well as stationary applications (potential examples include

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hydrogen internal combustion engine vehicles and hybrid electric vehicles; hydrogen engines and/or turbines for heavy-duty transportation applications such as forklifts or maritime vessels; and hydrogen gas turbines for power generation). These be used even in market segments where fuel cells have not yet become established [14].

LITERATURE SURVEY

The important reason for the lack of interest in FCEVs is their high purchase price. It will probably be necessary to offer additional financial incentives to buy a FCEV, e.g. in the form of higher subsidies. It is necessary to inform the public about the potential hydrogen has to contribute to a low-carbon transport sector and the storage of renewable energy [1]. Hydrogen is a highly versatile basic chemical. The most important material applications in industry are ammonia synthesis (fertilizers) and methanol synthesis. Although it is possible to use hydrogen as an energy source in heat engines (such as the internal combustion engine), that rarely occurs now [2]. Fuel cells can promote energy diversity and a transition to renewable energy sources. Hydrogen the most abundant element on Earth can be directly used. Fuel cells are also ideal candidates for a new trend of power generation, called distributed power generation [3]. H2FC SUPERGEN endeavours to produce and facilitate world class fundamental research across the entire Hydrogen and Fuel Cell landscape and link through to the point of commercialization [4]. The chemical properties of hydrogen can be a nuisance when implementing it in daily applications like motor vehicles for daily transportation needs [5]. Hydrogen fuel cell is environmentally friendly with useful end product of clean pure water, no percentage production of emissions such as NOx, CO, SOx, etc., zero capability of depleting the ozone layer, is a substitute to the conventional fossil fuels [6, 19, 20]. The fuel cell, an electrochemical device that generates electricity, is often referred to as “green power generators” and is rapidly becoming a globally high-potential industry. Many countries focus their policies on developing relevant technologies, and promoting the investment and education [7]. Fuel cells are an ideal source of both primary and standby power. They are clean, quiet, reliable, and produce consistent, high quality power. They are also cost-effective relative to other technologies on a life-cycle basis [8]. The advantages and disadvantages of fuel cells are important to take decisions for every application; specifically here are the most important. The main advantages includes Efficiency, Simplicity, Low emissions, Silence, Flexibility and wide application range The main disadvantages includes Cost and Hydrogen infrastructure [9]. The usage of hydrogen and fuel cell technologies can enhance and improve different aspects of our lives if it’s through economic, social and especially in environmental aspects [10]. Hydrogen gas can used in traditional gasoline-powered internal combustion engines (ICE) with minimal conversions. Even the production of hydrogen gas can be emissions-free with the use of renewable energy sources [11, 14]. Hydrogen ICE vehicles may provide sufficient early term fuel savings and carbon dioxide emission reductions that they may be worth promoting as a transition strategy [12, 17]. The potential advantages of solid H2-storage compared to gaseous and liquid hydrogen storage are Lower volume, Lower pressure (greater energy efficiency) and Higher purity H2 output [13, 16]. As a source of power for transportation, fuel cell systems have been improved recently by means of intensive development and probably will soon be used in the larger vehicles [15]. Hydrogen appears to pose risks of the same order of magnitude as other fuels. In spite of public perception, in many aspects hydrogen is

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actually a safer fuel than gasoline and natural gas [18].

WORKING PRINCIPLES

METHODS OF PRODUCING HYDROGEN

NATURAL GAS REFORMING

Synthesis gas (methane CH4), a mixture of hydrogen, carbon monoxide, and a small amount of carbon dioxide, is created by reacting natural gas with high-temperature steam and a pressure between 3 - 25 bars using a processing device called a reformer. The process is endothermic and requires a catalyst in addition to the carbon dioxide reaction in order to successfully produce hydrogen. This method is the cheapest, most efficient, and the most common way to extract hydrogen from hydrocarbons especially methane. The equation below shows the reaction that was mentioned to obtain hydrogen using the reforming method [5]

CH4 + H20 +heat ⇔ CO + 3H2

ELECTROLYSIS

Electrolysis can be defined as splitting of a water molecule into two hydrogen and one oxygen atom by use of a sufficient electrical current. As shown in Figure 1, two electrodes are inserted in a tank which is filled with water; a cathode carries a negative charge in addition to an anode which carries the positive charge. An alternating current is then passed through the electrodes so that it can start the splitting. Since the hydrogen is positively charged in the water molecule, it will leave the apparatus in the location of the cathode [5].

GASIFICATION

Gasification is the process in which coal or biomass is reacted with high-temperature steam and oxygen in a pressurized reactor called a gasifier and converted into gaseous components. The resulting synthesis gas contains hydrogen and carbon monoxide, which can be reacted with steam to produce more hydrogen [5].

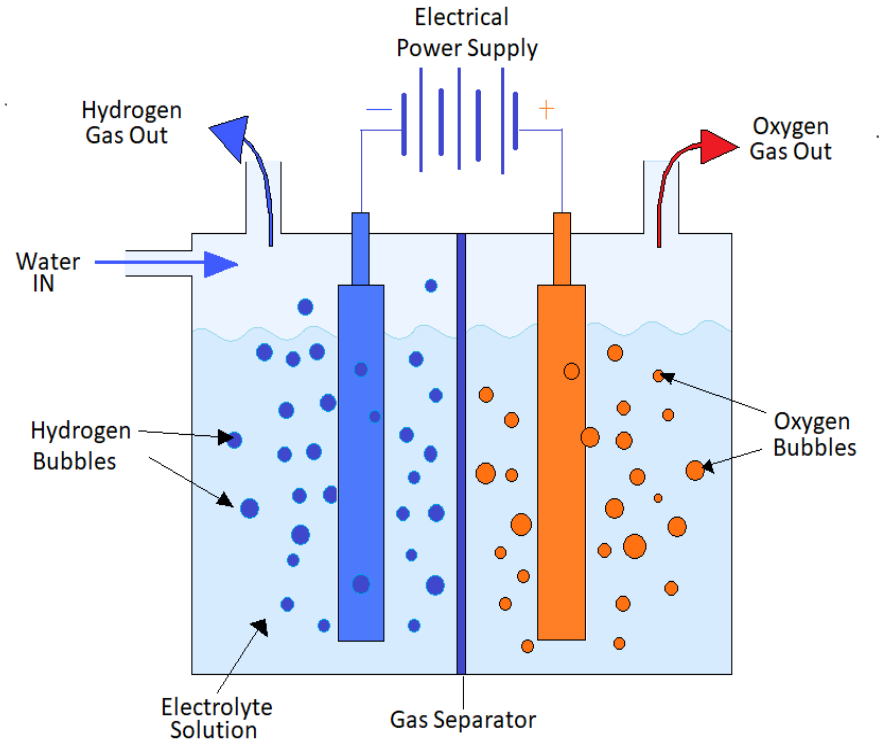

Figure 1.hydrogen production by electrolysis

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HYDROGEN FUEL CELLS

A fuel cell is a device that can efficiently capture and use the power of hydrogen. There are two main type of fuel cells; stationary and portable fuel cells [23].

Stationary fuel cells are used as a backup power source; provide power for remote locations and in distributed power generation. The latter is used to power personal vehicles, trucks, buses, marine vessels [23].

HOW DO HYDROGEN FUEL CELLS FUNCTION?

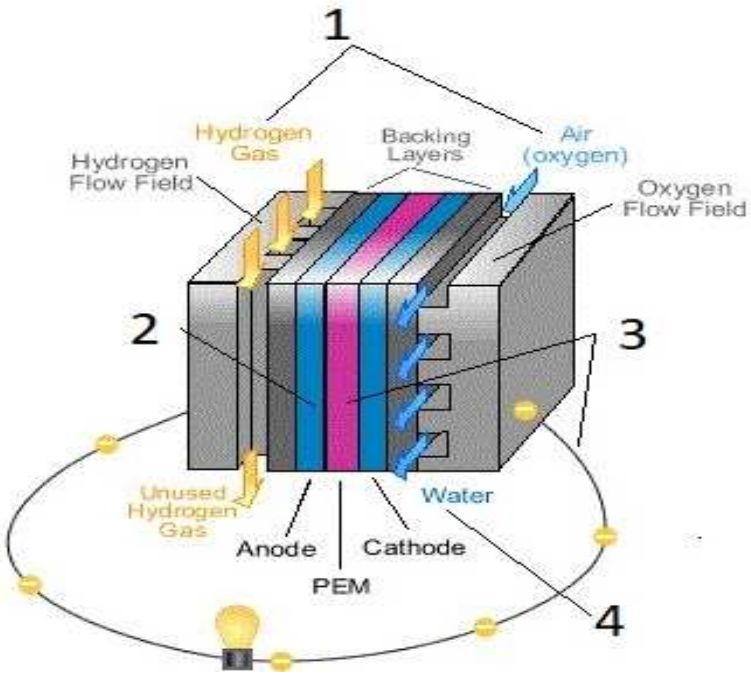
A fuel cell needs three main components to create the chemical reaction: an anode**,** cathode and an electrolyte**.** First, a hydrogen fuel is channelled to the anode via flow fields**.** Hydrogen atoms are ionized and carry only a positive charge. Then, oxygen enters the fuel cell at the cathode, where it combines with electrons returning from the electrical circuit and the ionized hydrogen atoms. After the oxygen atom picks up the electrons, it then travels through the electrolyte to combine with the hydrogen ion. The combination of oxygen and ionized hydrogen is the basis for the chemical reaction [23].

A polymer electrolyte membrane permits the appropriate ions to pass between the anode and the cathode. If the electrolyte gave free control for all electrons or ions to pass freely, it would disrupt the chemical reaction. At the end of the process the positively charged hydrogen atoms react with the oxygen to form both water and heat while creating electrical charge [23].

WHERE ARE FUEL CELLS USED?

Fuel Cells are used in both stationary and motive power applications for:

- Cars, trucks, buses, and recreational vehicles.
- Material handling equipment.
- Act as a primary power source for high-volume data centres or commercial, industrial, and residential buildings.
- Backup power source to critical computer and communications networks.
- Generating power on-site [23].



[https://www.fueleconomy.gov/feg/fc_pics/fuel_cell_still

Figure 2.Proton Exchange Membrane Fuel cell function

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ADVANTAGES

1. Hydrogen can be stored as a compressed gas or liquid, or in a chemical compound [10].
2. One of the ways to transport hydrogen is through pipelines, roads (via cylinders, cryogenic tankers, or tube trailers [10].
3. One of the characteristics of hydrogen is that it burns nearly pollution-free, one can look at it as a final clean fuel. The process of hydrogen is that when it is burned, it transforms into heat and hydrogen is that when it is burned, it transforms into heat and water vapour. Today in the type of engine which uses gasoline (aninternal-Combustion) the combustion will produce small amounts of other gases. The other gases are mostly oxides of nitrogen as at it is used as two-thirds of nitrogen as hydrogen. When using hydrogen there is a free carbon dioxide. One of the main changes for the climate change today, is the burning and the use of fossil fuels [10].
4. Hydrogen can be used to store energy from different sources which will result in an unlimited supply of clear fuel [10].
5. As we know it is pollution-free, no greenhouse gases are generated as there is no carbon in the fuel [10].
6. Hydrogen can be used as an energy carrier together with other alternative domestic fuels and technologies. It can enhance long-term energy security while mitigating the effects of air pollution and greenhouse gas emissions. Greenhouse gas emissions [10].
7. The use of hydrogen is that it can be cooled to produce liquid hydrogen [10].

DISADVANTAGES

1. Hydrogen is a gas which can be compressed and stored in cylinders. One of the major problems is the fuel tanks. Hydrogen is compressed which will contain less energy compared to liquid fuels like ethanol or gasoline [10].
2. Even though hydrogen is pollution-free, which in the future can make popular in transportation. However, some of the problem are: make popular in transportation. However, some of the problem are: how to store hydrogen in vehicles and high costs (in comparison to gasoline) [10].
3. The usage of Hydrogen is not a very good fuel for internal combustion engine, It is not a very good fuel for an internal combustion engine. For example, the companies of BMW, Mazda, and Ford have done several tests; one of the most efficient ways to use it is in fuel cell vehicles, however this is still in the experimental stage which are still in the demonstration stage [10].
4. As mentioned in the advantages on the issue of transporting, the use of pipelines is limited to only a few countries and states. For example in the US: large hydrogen chemical plants and refineries are concentrated in California, Texas and Louisiana [10].
5. Hydrogen must be produced from another energy source (upstream emissions unless renewable primary source is used) [10].
6. Currently, nearly all hydrogen produced and made is from natural gas. In that aspect, hydrogen costs more than natural gas [10].

CURRENT RESEARCH AND OBSTACLE

COMMON HYDROGEN MYTHS

HYDROGEN IS TOO DANGEROUS!

Many fuels with high energy densities - such as hydrogen and gasoline - must be handled with care. Like gasoline, propane, methane and other fuels, hydrogen has the potential to combust. This means that safety precautions

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must be taken so that hazardous combustion does not occur [21].

Producing hydrogen can create a hydrogen bomb.

Hydrogen bombs require that nuclear fusion be performed. This, in turn, requires deuterium and tritium - isotopes of hydrogen - in large quantities, which does not happen in nature [21].

HYDROGEN ISN'T A CLEAN FUEL.

A comparison between a combustion vehicle using gasoline or diesel and a car powered by hydrogen reveals that hydrogen is much cleaner as the only emission is water. In vehicles, hydrogen cannot compete with gasoline or diesel[21].

Actually, hydrogen powered vehicles are roughly twice as efficient as internal combustion vehicles. This means that for the same amount of energy from the fuel, a hydrogen car can go twice as far. This also means that for vehicles that use primarily electronic systems (steering, braking, etc.) fuel cells are actually more viable [21].

FUTURE SCOPE

Hydrogen in future being an important energy carrier will join electricity, since it can be made safely from renewable energy sources and is virtually non-polluting. It will also be used as a fuel for 'zero-emissions' vehicles, to heat homes and offices, to produce electricity, and to fuel aircraft. Hydrogen has the potentiality to reduce reliance on imported energy sources such as oil. Hydrogen played a bigger energy role and become a widely used alternative to gasoline, many new facilities and systems must be built to make use of hydrogen as fuel [22].

A key development in industries in Canada and internationally in recent years shifted from small bench and laboratory demonstration projects to larger integrated hydrogen system projects. These demonstration projects provide the basis for testing and evaluating fuel cell and hydrogen technologies in an integrated interactive system which includes transport, stationary applications with hydrogen transport, storage and refuelling platforms. These projects also provide a more high-profile exposure and general public awareness [22].

In the near future, fuel cells will supply power to our cars, with hydrogen replacing the petroleum fuel that is used in most vehicles today. Unlike a typical battery, which eventually goes dead, a fuel cell continues to produce energy as long as fuel and oxidant are supplied [22].

CONCLUSION

It has been proved from the study, it is beneficial to use hydrogen as fuel. In the future, hydrogen based stationery system can help supply some or all of the power demanded with additional advantages of higher reliabilities.

This study considered the ways by which hydrogen can be produced and used as fuel in order to minimise the use of non- renewable energy resources.

The role and use of fuel cells in near term stationary and portable application could be significant, especially if opportunities for integrated systems are considered.

Technologies must be developed in order make more use of hydrogen as fuel which will lead to better and sustainable environment.

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