

Investigations on Hydrogen Fuel Cell

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Abstract

The rising pollution across the globe has become a problem that one should be concerned about. The rise in temperature across the globe, rise in the rate of ozone layer depletion, contamination of the air is all due to the pollutants from the exhausts of automobiles, factories, industries. To address all these and many other problems, hydrogen fuel cell technology is ongoing research that could be a way to solve the lately arising problems due to conventional fuels which we have been using for the past few decades. A hydrogen fuel cell is an electromagnetic fuel cell that uses hydrogen as a fuel to generate electricity undergoing various redox chemical reactions. It mainly focuses on the problem nowadays faced and helps in generating electricity in an eco-friendly way. A hydrogen fuel cell is a way to overcome carbon emissions that take place during the process of extraction of fossil fuels and combustion process in various sectors across the globe which are widely in use.

In this research paper, you will get to know the history behind the research and development of fuel cells and as we move ahead, we will know how an actual hydrogen fuel cell is designed to work, how hydrogen fuel cells work and the actual process that is taking place inside the fuel cell which leads to the production of electricity. A Hydrogen fuel cell is potentially a fuel cell that runs on hydrogen. Hydrogen can be produced in various ways both renewable, pure and non-renewable, not so pure. To maximize efficiency, we utilize water to produce renewable and the purest possible hydrogen. This helps in generating maximum power as output that can be put to use in various fields.

Keywords: Hydrogen fuel cell, Polymer exchange Membrane, Renewable fuels, electric vehicles, Electrolysis;

1. Introduction

1. Fuel Cell History

A fuel cell is described as an electromagnetic cell that converts chemical energy into electrical energy. This conversion process occurs in the presence of an oxidizing agent undergoing multiple redox reactions. A fuel cell requires a continuous supply of oxygen through air and chemical energy in the form of fuel to undergo a series of redox reactions leading to the production of electrical energy. The most commonly used fuel is hydrogen. Unlike batteries which are recharged after every use, provided an uninterrupted fuel source, it can generate electricity as long as the supply lasts.

The first Fuel cell was invented in the year 1838 by Sir William Grove. And the first Hydrogen-Oxygen Fuel cell was invented by Francis Thomas Bacon in the year 1932. This was also named the Bacon cell after Sir Francis Thomas and the alkaline fuel cell for the presence of alkaline chemicals.

1.2 Working of fuel cells

Fuel cells are of various types but are commonly made up of three main segments namely: the negative terminal (anode), the positive terminal (cathode) and the conducting medium (electrolyte). Two different reactions occur at the three segments inside the fuel cell. This reaction consumes fuel during the reaction and produces either water or carbon-di-oxide alongside electrical energy. This electrical energy is used to power various electrical devices and appliances once, stored properly.

The rate of reaction is improved with the help of a catalyst to oxidize the fuel, producing a positively charged ion and a negatively charged electron. Here, the electrolyte used is specially designed to allow the flow of ions and restrict the flow of electrons to maintain equilibrium and steady flow of ions and electrons throughout the reaction process.

The oxidized fuel produces positively charged ions and negatively charged electrons. The electrons move through a solid conducting medium that is a wire producing an electric current. While the ions move to the cathode through the conducting medium in this case the electrolyte. Once, the electrons move to the electrode and ions to the cathode. The electrons now react with a chemical to create water or carbon dioxide.

1.3 Types of fuel cells

- A. Polymer Electrolyte Membrane Fuel Cell.
- B. Direct Methanol Fuel Cell.
- C. Alkaline Fuel Cell.
- D. Solid Oxide Fuel Cell.
- E. Molten Carbonate Fuel Cell.
- F. Reversible Fuel Cell.

1.4 Importance of fuel cells

Fuel cells have numerous applications, providing power to various utilities across various sectors like transport, power storage grids, commercial uses, residential infrastructures, and reversible systems.

The fuel cell is far more beneficial than conventional sources of energy, mostly produced by non-renewable sources that require an intense extraction process and cause mass pollution during the conversion of the fuel into electrical energy. Whereas, fuel cells undergo an environmentally friendly reaction producing water or carbon dioxide which do not cause any harm to the environment. All these things considered, the fuel cell is one of the best possible ways to face a global crisis of depleting the ozone layer and rapid climate change.

2. Hydrogen Fuel Cell

Hydrogen fuel cells similar to all the fuel cells work in the same way. It converts the energy stored in the hydrogen molecules to electricity undergoing various electrochemical, redox reactions. It is carried out by a cathode and an electrode separated by an electrolyte membrane.

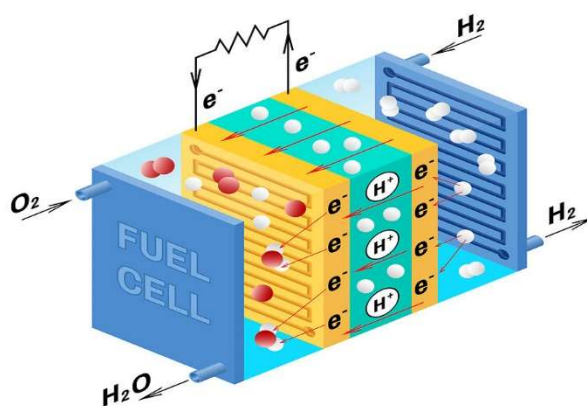


Fig.1. Polymer Electrolyte Membrane (PEM) Fuel Cell

The hydrogen fuel cell is one of the best choices to generate electricity from hydrogen. It provides high efficiency, low noise, and very few moving parts as compared to its counterparts that being, internal combustion engines. Fuel cells come into use for stationary and locomotive electricity power generators from the hydrogen fuel cell.

2.1 Production of hydrogen fuel

Hydrogen is one of the naturally occurring elements on earth. Not found in its purest form, it can be extracted from abundant sources by performing various reactions. In the early 16th century, a reaction between acids and metals led to the first, artificial production of Hydrogen gas. Henry Cavendish in the year 1766 was the first to discover that hydrogen is a different substance that when burnt produces water. Hydrogen is often produced as a by-product of other reactions. It can be produced in various ways such as:

- a. Water Electrolysis.
- b. Methane pyrolysis.
- c. Metal-acid reactions.
- d. Serpentinization reaction.

Out of the available processes, electrolyzes splitting water to produce oxygen and hydrogen using electricity is one of the most developed processes which is put to use commercially for the production of hydrogen. Although this has a drawback of consuming electricity, it can be overcome by using a polymer electrolyte membrane (PEM).

2.2 Advantages of hydrogen fuel cell

The Hydrogen fuel cell is one of the most efficient forms of energy that can be put to use for various purposes. A few of the advantages of hydrogen fuel cells over conventional energy sources are as follows:

- a. A hydrogen fuel cell offers a pretty high level of energy efficiency that can exceed about 80%.
- b. As hydrogen is produced through electrolysis, there are no harmful byproducts from the reaction. Also, the process of conversion of chemical energy to electrical energy taking place inside a hydrogen fuel cell run vehicle produces water as an end product. Hence, the emissions from a fuel cell are virtually considered to be zero.
- c. The production of hydrogen fuel cells can practically be worked out with negligible emissions cost.
- d. Hydrogen fuel cells provide an effective method of energy storage that can retain energy with minimal loss for a long period.
- e. Hydrogen is one of the most abundant elements in the universe, it is a renewable source of energy that is apt for minimal carbon emissions to produce heat and power that is eco-friendly.

2.3 Drawbacks of hydrogen fuel cells

Hydrogen fuel cell though it comes with a lot of advantages has quite a few drawbacks that restrict the application of the hydrogen fuel cell at greater stages. Drawbacks of hydrogen fuel cells are quite significant and are as follows:

- a. Despite hydrogen being one of the most abundant elements in the universe, it is not available in its purest form. This requires a lot of pre-processing to extract hydrogen from the atmosphere to its purest of forms that can be used to recharge fuel cells. As a result, the energy used to extract hydrogen is more than the energy produced using it.
- b. Hydrogen is highly flammable when compared to regular fuel. Hence, it is difficult to contain it when compared to other fuels.
- c. Manufacturing of hydrogen is expensive as the catalyst required is platinum most of the time to speed up the reaction.
- d. As fuel cells have been used for decades as of today, hydrogen is a newly underdeveloped solution to the problem faced in the past. The infrastructure required to extract fossil fuels is quite well established and those required for the extraction and production of hydrogen are yet to be built across the globe rapidly.
- e. Hydrogen is still under development, making it a hit or miss for the present prevailing problems being faced. Also, the hydrogen fuel cell may end up being a problem rather than a solution to the problems. This makes hydrogen a recurring solution to the problem that cannot be solved for a long time.

3. Applications of Hydrogen Fuel Cell

The hydrogen fuel cells are still under research and development and have a long way to go before they become a renewable and dependable source of energy for industrial, commercial, and domestic use. A few of the applications of hydrogen fuel cells are as follows:

- a. Mobile power generation.
- b. Automobiles (Trains, Buses, Cars).

- c. Marine applications (Boats, Submarines).
- d. Unmanned Aerial Vehicles (UAVs).



Fig.2. Breeze train powered by Hydrogen.

4. Conclusions

A Hydrogen fuel cell is an eco-friendly way to produce electricity without any harmful byproducts during the production process in which, hydrogen is used as a fuel. A hydrogen fuel cell is a basic fuel cell that roots on hydrogen as a fuel source to undergo chemical reactions. It undergoing all the chemical processes produces water as a byproduct. A Hydrogen fuel cell uses a Polymer Exchange Membrane (PEM) to effectively control the flow of electrons and protons that is, the ions within the fuel cell to avoid collisions and unnecessary flow of ions in the wrong directions and increase the efficiency of the reaction process. It makes use of pure hydrogen is capable of producing electricity with an efficiency that can go up to 80%. All this considered, hydrogen is a renewable source of energy as it can be produced by splitting water into oxygen and hydrogen by various electrochemical redox reactions.

Hydrogen fuel cells are being used in various sectors from mobile electricity generators, Unnamed Aerial Vehicles (UAVs), Marine applications, to run Automobiles like buses, trains, cars and many more. Even after all this, hydrogen could not solve the problem of eco-friendly fuel. Though it is said to solve many problems to an extent like pollution, zero-emission, reduction in the sounds produced during combustion, better efficiency. Yet, problems like production, transportation, refuelling and many more are quite expensive compared to fossil fuels which leave us with a question that is, is hydrogen a solution to all these problems as it leads to many other new problems.

And to finally sum everything up, hydrogen fuel cells stand out when compared to other sources of energy like fossil fuel combustion engines, electric vehicles. With better research and development of infrastructures for production and transportation of hydrogen, manufacturing of fuel cells a better way to use hydrogen in daily life activities can be found.

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