DESIGN OF A PEM FUEL CELL FOR FCV 2021 11 05

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DESIGN OF A PEM FUEL CELL FOR FCV

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Abstract

The main goal of fuel cells is to generate water, heat, and electricity by electrochemical reactions. Understanding the functioning of the fuel cells is at the base of developing and designing the fuel cell vehicle. This report covers fuel cells in general and focuses on the operational process and types of fuel cells. Furthermore, examples of design features and form will be discussed. A Proton Exchange Membrane fuel cell is a polymer electrolyte membrane (PEM) fuel cell that, like water and air as its reactant, produces only pure H2O as the end product. This report is about fuel cells from a design perspective. What makes a good design, and the intention of the project's plan.

Keywords: Bipolar plates, Design objectives, Electrochemical reactions, Fuel cells.

Contents

Abstract 1

Introduction

A fuel cell is an electrochemical device that produces electricity. A fuel cell consists of two electrodes, called an anode and a cathode, where the energy reactions occur; hydrogen is fed to the anode compartment, and

oxygen is provided to the cathode compartment. Hydrogen tends to be attracted to hydrogen electrodes, while oxygen tends to be attracted to oxygen electrodes, causing both species' migration towards their respective electrodes. Fuel cells are used in many devices such as spacecraft or laptops, but most importantly can produce electrical power needed in vehicles. The design of the fuel cell requires precise attention to ensure its performance meets user requirements.

The advantages of fuel cells include higher efficiency, cheaper, higher power density, improved technology, and better performance with lower temperatures. Proton-exchange membrane (PEM) fuel cells have been used in various applications for decades but have become more competitive as materials have become less expensive and the technology has improved. Active materials for PEM fuel cells are now available from a wide range of suppliers. One of the most important developments is a new class of carbon-based electrodes that work better at lower temperatures and generate higher power density, making them particularly suitable for automotive applications. With their high efficiency and long life, they can significantly reduce energy use; cut greenhouse gas, CO2 emissions; and reduce the cost of operating electric vehicles. With a Proton Exchange Membrane (PEM) fuel cell, you get a car with all the advantages of a modern car – acceleration, handling, braking, and safety – as well as the ability to refuel at home in minutes.

III.Literature Review

III.II Fuel cell components

The fuel cell is constructed by sandwiching two electrodes between two ion-conducting polymer membranes to form catalysis layers. Then the electrodes are pressed, packaged, and separated to assemble a fuel cell component. The fuel cell components are made of mechanical parts, including the membrane electrode assembly (MEA), bipolar plates, anode, cathode, and separator that provide an interface between fuel cell and electrolyte. A fuel cell is a device that converts the chemical energy from a fuel into electricity through electrochemical oxidation. Fuel cells are similar to batteries in that both convert chemical energy into electrical energy. However, while batteries use an electrochemical process to convert chemical energy into electrical energy, fuel cells use catalytic reactions between hydrogen and oxygen from fuels, oxidants supplied from an external source, and electrons from a terminal voltage source.

III.III Fuel cell types

Fuel cell technology is being used in the development of new batteries that have higher power density. The fuel cells are quiet, have long operational lives, and are clean. Fuel cell types include; Alkaline Fuel Cell

(AFC), Direct-Exchange Membrane Fuel Cell (DMFC), Solid-Oxide Fuel Cell (SOFC), Proton-Exchange Membrane (PEMFC), Molten-Carbon Fuel Cell (MCFC), and Phosphoric Acid Fuel Cells (PAFC).

Proton Exchange Membrane Fuel Cell (PEMFC).

The technology of the PEMFC can be used with heat recovery to heat buildings, power industrial processes, and even transport energy. Compared to most other fuel cells, the PEMFC has less weight and is more cost-effective. However, they are made from polymers which are inherently less durable than metal oxides. The technology behind fuel cells was first identified by Nicholson and further researched in the late 19th century. Fuel cell membranes have been modified to adopt aqueous derivatives solutions like amino acids and amino acid esters. Fuel cell technology holds potential to be used worldwide in a broad range of industries such as home electronics, medical applications, material handling equipment, motor vehicle applications, and aerospace applications.

PEMFCs are lighter and offer less volume than other fuel cell types while delivering high energy density. They can be used in situations that require flexible power generation like vehicles or portable electronics. Furthermore, the units only need water, hydrocarbons, and oxidant from the environment to function. The PEMFCs operate at a low temperature of roughly 80°C (176°F), unlike other fuel cells, which need to run at much hotter temperatures. The Proton Exchange Membrane fuel cell, or PEMFC, is a high energy density and then has minimal weight and volume compared to other types of fuel cells. They use a solid polymer as the electrolyte and catalyzed carbon electrodes.

Phosphoric Acid Fuel Cell (PAFC).

The phosphoric acid fuel cells (PAFC) are used for stationary power generation. PAFCs have essential applications in buildings, transportation, the military, and the space program. Phosphoric acid fuel cells have been used until recently, mainly in spacecraft, to generate electricity from chemical reactions. In 2003, the first phosphoric acid fuel cell bus began transporting passengers at Japan's Tama New Town project. Unlike diesel engines, which contribute significantly to air pollution, phosphoric acid fuel cells produce only water vapor and heat when being charged. Now, phosphoric acid has been found potentially useful for residential services.

This phosphoric acid fuel cell produces electricity, heat, and water. The anode processes the gases delivered under pressure by the gas supply system. Fuel is burned in a solid ash-free process without the release of polluting substances into the environment. Operating temperatures are more than 750°F (400°C); this permits high efficiencies at low operating pressures. PAFCs are used for stationary power generation, and some PAFCs are used to power large vehicles such as city buses.

Furthermore, this type of fuel cell uses liquid phosphoric acid. Liquid phosphoric acid is held in a Teflon-bonded silicon carbide matrix and porous carbon electrodes with a platinum catalyst. Because carbon monoxide is linked to the platinum catalyst at the fuel cell's anode, phosphoric acid fuel cells (PAFCs) are quickly poisoned by carbon monoxide, lowering their efficiency. When co-generation of electricity and heat is used, the efficiency is still decreased because carbon

Molten Carbonate Fuel Cell (MCFC).

Molten carbonate fuel cells (MCFCs) are a kind of molten electrolyte solid oxide fuel cell that share many features of phosphoric acid fuel cells. Molten carbonate fuel cells (MCFCs) operate at a high temperature of around 650°C (1,200°F). Because of this higher operating temperature, non-precious metals can be utilized as catalysts at the fuel cell's anode and cathode. MCFCs have a potential for increased efficiency, reaching 65 percent compared to a 37–42 percent efficiency for phosphoric acid fuel cells.

The Molten Carbonate Fuel Cell (MCFC) is a type of solid oxide fuel cell. The electrolyte of the molten carbonate fuels cells can be a molten carbonate salt combination. MCFCs operate at a high temperature of around 600 Celsius (1,100 Fahrenheit). The high operating temperature allows non-precious metals to be used as catalysts at the anode and cathode. MCFCs operate at high temperatures, which would enable greater efficiencies in the conversion of hydrogen to electricity when compared to phosphoric acid fuel cells. Molten carbonate fuel cells (MCFCs) are a type of regenerative fuel cell in which carbon dioxide is used, rather than oxygen or steam, to improve fuel cell efficiencies. Molten carbonate fuel cells utilize molten carbonate salts at the anode and cathode catalytic surfaces.

Solid Oxide Fuel Cell (SOFC).

Solid oxide fuel cells (SOFCs) operate at a high temperature of roughly 1,000°C (1,830°F), eliminating the requirement for a precious-metal catalyst. Furthermore, the ceramic compound is used as the electrolyte in solid oxide fuel cells (SOFCs). The ceramic composition is nonporous and very hard. Again, solid oxide fuel cells (SOFCs) in converting fuel to electricity is approximately 60%. In some applications, such as those that employ co-generation, overall fuel consumption efficiencies may exceed 85 percent. Furthermore, because solid oxide fuel cells (SOFCs) are not sensitive to carbon monoxide, they are not poisoned by it. Since the introduction of solid oxide fuel cells (SOFCs) leads to a delayed starting, thermal shielding is required to protect users and preserve heat, which poses problems when shipping owing to its size.

Alkaline Fuel Cell (AFC).

In the United States space program, alkaline fuel cells (AFCs) were used to generate water and electrical energy on the spaceship. As the first type of fuel cell used in and developed for the US space program. Furthermore, at the anode and cathode of the fuel cell, an electrolyte (potassium hydroxide solution in water) and a catalyst (any non-precious metal) are used. Alkaline fuel cells (AFCs) using a polymer membrane as the electrolyte was developed. Alkaline fuel cells (AFCs) are similar to PEM fuel cells in that an alkaline membrane is used rather than an acid membrane. Furthermore, the functioning of the alkaline fuel cells.

III.IV Bipolar plates types

In a PEM fuel cell stack, the bipolar plate serves many functions. It also believes the fuel cell stack to be the most expensive and troublesome. A bipolar plate's primary function is to provide reactant gases to gas diffusion electrodes (GDE) through flow channels. Furthermore, the bipolar plate is also known as a flow-field plate since reactant transport is dependent on the flow-field design, as demonstrated in Figure 2, which depicts several flow channel configurations.

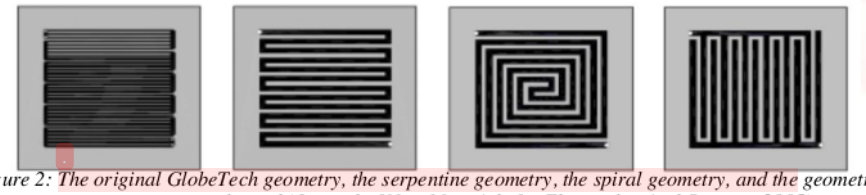


Figure 2: The original GlobeTech geometry, the serpentine geometry, the spiral geometry, and the geometry of the discontinuous channel (Journal of New Materials for Electrochemical Systems, 2005)

As shown in figure 2, the bipolar plates types are:

- The original GlobeTech geometry.
- The serpentine geometry.
- The spiral geometry.
- The discontinuous channels geometry.

The bipolar plates must provide the electrical connections between the various cells. Furthermore, they must adequately remove the water created at the fuel cell's cathode. Again, the bipolar containers must be robust enough to support the stack assembly, impermeable to gases, and easily mass-produced. Furthermore, because weight and volume are essential factors in transportation, they should be light and small. The bipolar plates are continually in touch with the acidic water (pH 5) created by the stack's operating conditions, necessitating excellent chemical stability and corrosion resistance. During corrosion, oxides are generated that might cause poisoning.

IV. Concept Design

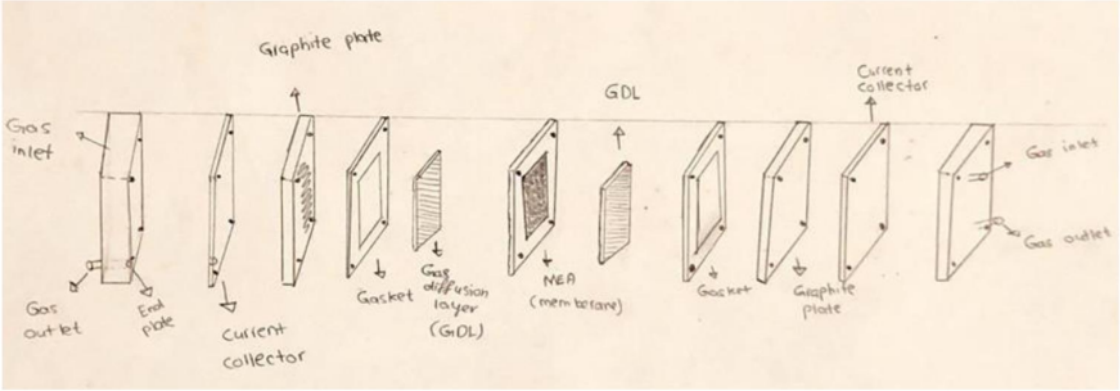


Figure 3: Hand drawing of the fuel cell design

- One gas diffusion layer is put before the gasket on the cathode side and the other after the gasket on the anode side.
- The anode and cathode sides were separated by a membrane electrode assembly (MEA) in the center.

Discussion

This project must design and construct a fuel cell for a 115-kW car. The fuel cell design was developed and presented as a future mechanical engineer, as illustrated in figure 3. To further enhance

the fuel cell, a bipolar plate was added, a layer made up of channels that allow gases to take a long time to reach the catalyst layer through the gas diffusion layer. As a result, the fuel cell's efficiency will improve. The graphite plate is a bipolar plate similar to the one depicted in figure 3.

VI. Conclusion

Understanding the operation of the fuel cell is essential for engineering designers while sketching and developing the fuel cell. The function of this fuel cell design is for hydrogen gas to enter the anode side of the fuel cell and be divided into electrons and protons. The hydrogen proton reaches the anode side of the fuel cell, where it interacts with the oxygen gas to generate water. On the other hand, electrons are liberated and driven through the external circuit to form an electric current. As a prospective mechanical engineer, I proposed a developed fuel cell design after learning about the operation of the fuel cell. A bipolar plate (graphite plat) was added to the fuel cell design.

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GENERAL COMMENTS

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