Thermal and Electrical Performance Evaluation of a Hybrid Fuel Cell Power Unit

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ABSTRACT

The world is moving toward fuel cell technology as a means of decarbonizing the global system. These days, fuel cells are being debated for a wide range of reasons as clean and effective power sources. Fuel cells are a viable and intriguing option for an environmentally friendly energy source because of their benefits, which include changeable geometry, large storage capacity, no self-discharge, and the possibility of low production costs. Fuel cells have the potential to provide clean, sustainable electricity to the world by using hydrogen as fuel. The article talks about utilizing fuel cell and solar module hybridization to generate electricity.

Keywords: hybridization, redox process, fuel cell, and electrolyte.

1. INTRODUCTION

Fossil fuels contribute to approximately 60% of the world's energy output, and burning and producing them impact the environment. Also, as the global population increases, consumption of fossil fuels will increase whereas their sources will dwindle. Our future living standards require alternatives.

Remedies that meet market needs to produce economical, reliable, high-quality energy while reducing toxic emissions and controlling pollution. Fuel cells can potentially serve as a future alternative. A fuel, either hydrogen or a basic hydrocarbon, is electrochemically oxidized by a fuel cell system to produce electricity. Fuel cell systems can attain high electrical efficiency under diverse size and part-load conditions. Fuel cell systems typically emit less carbon dioxide and trace levels of regulated air pollutants.

By the fact that they can commonly operate as an internal impedance voltage source, fuel cell systems are similar to other devices for generating or storing energy such as batteries and solar cells. Provided there is fuel and an oxidant, fuel cells produce power indefinitely. Having gone through all the above details, we developed a model based on a fuel cell and solar module for hybrid energy supply.

2. LITERATURE REVIEW

A review of research articles from different researchers reveals a range of commendable efforts and solutions made for the advancement of fuel cells and their uses. Sir William Grove, a Welsh physicist and lawyer, conducted research on the creation of his first unrefined fuel cells in 1838. He combined copper, sheet iron, and ceramic plates, as well as a copper sulfate and diluted acid solution. The carbonate cycle and modern solid oxide fuel cells were developed in 1920 thanks to fuel cell research conducted in Germany. Francis Thomas Bacon created a fuel cell in 1932 that uses hydrogen and oxygen to generate electricity.
Sir Bacon created a 5 kW fuel cell in 1959 that was capable of powering a welding machine.
The Apollo spacecraft's fuel cell-based power system was manufactured by General Electric Company in 1960. Roger Billings created the first hydrogen fuel cell vehicle in 1991. The first fuel cell-powered bus was created in 1993. Toyota introduced fuel cell-powered vehicle prototypes in 1997. Toyota introduced the Mirai, a fuel cell-powered vehicle, in 2015. Hyundai introduced the Nexo, a fuel cell-powered vehicle, in 2018. The first business to produce and market a sizable, dormant fuel cell system for use as a cogeneration power plant in big office buildings, hospitals, and institutions was UTC Power. The US Senate declared October 8, 2015, to be National Hydrogen and Fuel Cell Day in appreciation of the fuel cell sector and America's contribution to fuel cell development.

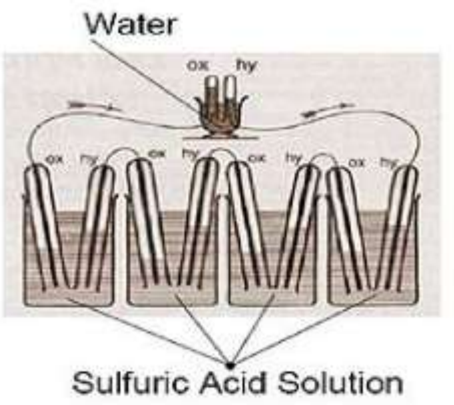

Figure 1: Grove crude fuel cell

3. CONSTRUCTION OF FUEL CELL

Although fuel cells exist in a variety of forms, they all function generally in the same way. The electrode, electrolyte, and cathode are its three neighboring components. At the boundaries of the three, two chemical reactions take place. several sections. The two reactions ultimately result in the burning of fuel, the production of carbon dioxide or water, and an electric current that can be used to power electrical equipment, also known as the load. Let's look at the hydrogen fuel cell example in figure 2 above. The catalyst in a fuel cell makes the reaction between hydrogen and oxygen simpler. A substance that accelerates a chemical reaction without being consumed by it is called a catalyst. Typically, it is composed of extremely thin layers of platinum powder applied to carbon paper or fabric. The catalyst has a rough texture. and porous, allowing hydrogen or oxygen to reach the platinum's extreme surface area. The electrolyte mixture—potassium hydroxide, or KOH; phosphoric acid; methanol, etc.—determines the type of fuel cell.

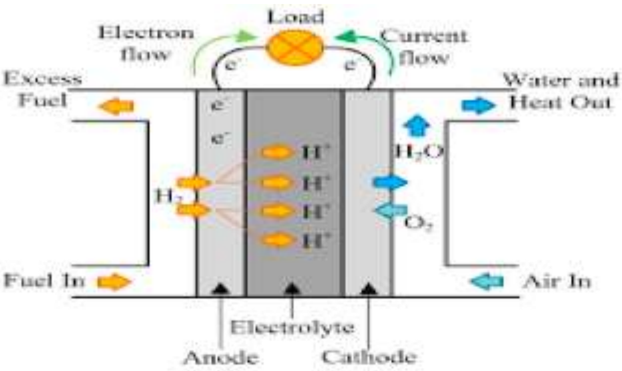

Figure 2: Hydrogen Fuel Cell (HFC)

4. WORKING OF FUEL CELL

The fundamental purpose of a fuel cell is to generate energy, which can power a metropolis or something as basic as a lightbulb. Within a fuel cell, a straightforward chemical reaction is responsible for producing electricity, which is then sent back into the cell to complete the electric circuit. This At the anode, hydrogen atoms are introduced to start the chemical process. At this point, a chemical process strips the electrons from the hydrogen atoms. A positive electric charge is now transmitted by the hydrogen atoms. Current flows via the wires thanks to the persistently negatively charged electrons.

At the cathode, oxygen atoms are added. They attach themselves to the electrons that the hydrogen atoms have left behind. The oxygen atoms and negatively charged electrons would either unite with the positively charged hydrogen ions at this point or after wandering through the anode, depending on the type of cell.

Hydrogen + Oxygen = Water Vapor + Electricity

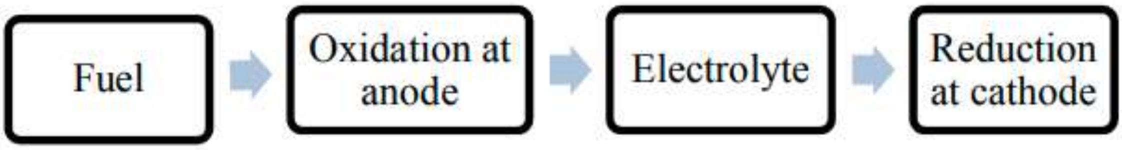

Figure 3: Fuel Cell Process

5. PERFORMANCE OF FUEL CELL

We must first observe the fuel cell's efficiency before utilizing it in any application. Fuel cell efficiency has a direct impact on storage needs and operational costs. Because gasoline must be carried with a cell in moving operations like trucks and autos, efficiency is the most crucial component. As stated by the U.S.

According to the Department of Energy, fuel cells typically have an energy efficiency of 40–60%. Compared to some other energy producing technologies, this is more sophisticated. For instance, an automobile's internal combustion engine (IC engine) typically uses about 25% less energy. Efficiency of fuel cell may be measured by calculating the ratio of electricity produced by fuel cell to the hydrogen (fuel) used by the cell.

The following TABLE I shows the different types of fuel cells and their efficiency.

Table I: Different Types Of Fuel Cells and Their Efficiency

S.no	Type of fuel cell	Efficiency
1	Polymer Electrolyte membrane fuel cell	30%-40%
2	Solid Acid Fuel Cell	40%
3	Solid Oxide Fuel Cell	50%
4	Molten Carbonate Fuel Cell	50-70% With cogeneration
5	AFC (Alkaline Fuel Cell)	60%
6	Phosphoric acid fuel cell	30-70% with cogeneration
7	Direct Methanol Fuel Cell	30%

MCFC and PAFC plants are cogeneration plants which includes the production of energy and useful heat in the form of steam and hot water takes place.
Model consists of four main parts. 1) Fuel cell: Consist of two electrodes immersed in electrolytic solution. It convert chemical energy into electrical energy. 2) Solar panel: Converts solar energy to electrical energy. 3) DC control unit or Hybridization unit: Hybridize outputs of the fuel cell and PV panel by controlling various parameters. 4) DC link 5) Load.

6. CONCLUSION

It is clear that the idea explained in this research can be used as a future alternative for hybrid energy production. The development and history of fuel cells throughout the years were explained in this paper. It also illustrates the characteristics of some types of fuel cells. Unlike other power sources such as photovoltaics, the fuel cell system has a control system that manages the plant's balance. The fuel cell is more efficient than PVs or wind energy because it supplies power to the load consistently as long as it is fueled, like natural gas (hydrogen). A successful replacement for the fuel used in automobiles today are hydrogen fuel cells. They provide a way for electric vehicles to run efficiently and cleanly. The only disadvantage is that, compared to other fuels, hydrogen is very costly to transport and store. Fuel cells will be clean and efficient power sources in the future as their price drops with improvement in technology.

7. REFERENCE

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