# Challenges and Opportunities of Fuel Cell

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## Abstract

**Fuel cell is a kind of power generation device that directly converts chemical energy into electrical energy. It stands out in various fields with its advantages of high power generation efficiency, low pollution and low noise. In this paper, the basic principle and classification of fuel cell are described, what's more, the application of fuel cell is also introduced. Finally, the problems faced by the development of fuel cell are discussed and the future of fuel cell is prospected.**

## Keywords

**Fuel cell, Basic principle, Classification, Application.**

## 1. Introduction

Energy is the basis of the survival and development of human society. With the rapid development of human society, the demand for energy is also increasing rapidly, but it is not a long-term solution for human beings to rely on fossil energy alone. On the one hand, the reserves of fossil energy are limited, and its mining cost is rising. On the other hand, the massive use of fossil fuels not only causes environmental pollution, but also seriously harms people's health. Therefore, it is urgent to find a clean, efficient and renewable energy production mode to achieve the sustainable development of human society. After repeated experiments and screening, hydrogen energy has entered people's field of vision, among which fuel cell technology is an important technical means to achieve hydrogen energy recycling. Fuel cell is a kind of energy conversion device that uses the energy in fuel to provide electric energy like a battery, that is, under the action of electric catalyst, the chemical energy in renewable fuel is converted into electric energy. Unlike batteries, fuel cells do not store the chemical fuel needed for reactions, but provide a place for chemical reactions. When the battery works, the fuel is supplied by the outside and reacts on the electrode. Only when reactants are continuously input and products are continuously discharged, fuel cells can generate electricity continuously. We can vividly compare it to a "power plant". Fuel and air are fed into the fuel cell. After processing, electricity will be produced miraculously[1].

At the same time, fuel cell has the advantages of high power generation efficiency, little environmental pollution, high specific energy, low noise, wide fuel range, high reliability and easy construction.

Fuel cell power generation is not limited by the carnot cycle. In theory, it could be 85 to 90 percent efficient. However, due to the limitation of various polarization during operation, the energy conversion efficiency of fuel cell is about 40% ~ 60%. If the realization of heat and power co-supply, the total fuel efficiency can be up to more than 80%. When fuel cells are fueled with hydrogen-rich gases such as natural gas, their carbon dioxide emissions are more than 40 percent lower than those from thermally driven processes, which is important to mitigate the planet's greenhouse effect. In addition, because the fuel gas of the fuel cell must be desulfurized before reaction, and according to the electrochemical principle to generate electricity, there is no high-temperature combustion process, so almost no emissions of nitrogen and sulfur oxides, reducing the pollution to the atmosphere. The specific energy of a liquid hydrogen fuel cell is 800 times higher than that of a nickel-cadmium battery, and the specific energy of a direct methanol fuel cell is more than 10 times higher than that of a lithium-ion battery (the battery with the highest energy density). At present, the actual specific energy of fuel cells, though only 10% of the theoretical value, is still much higher than that of conventional batteries. The fuel cell has simple structure, few moving parts and low noise when working. Even in the vicinity of an 11MW fuel cell power plant, the noise measured was 55dB lower. As for fuel cells, all materials containing hydrogen atoms can be used as fuel, such as natural gas, oil, coal and other fossil products, or methane, alcohol, methanol, etc. Therefore, fuel cells are well suited to the needs of energy diversification and can slow down the depletion of mainstream energy. When the fuel cell load there is a change, it will soon response. Whether it is in overload running power rating above or below the rated power, it can withstand and efficiency. Due to the operation of the fuel cell highly reliable, can be used as all kinds of emergency power supply and uninterrupted power supply. The fuel cell has a modular structure, easy installation and maintenance, don't need a lot of auxiliary facilities. The fuel cell power plant design and manufacture is very convenient[2].

## 2. Basic principle of fuel cell

The fuel cell is an electrochemical device with the same composition as a conventional battery. Its single cell is composed of two electrodes (the negative electrode is the fuel electrode and the positive electrode is the oxidant electrode) and an electrolyte. The difference is that the active material of ordinary battery is stored in the battery, so the battery capacity is limited. The positive and negative electrodes of fuel cells do not contain active substances, but are catalytic conversion elements. So fuel cells are literally energy-conversion machines that convert chemical energy into electricity. When the battery is in operation, the fuel and oxidant are supplied externally and react. In principle, as long as the reactant is continuously input and the reaction product is continuously eliminated, the fuel cell can continuously generate electricity.

The main components of fuel cell are electrode, electrolyte separator and collector.

The electrode of fuel cell is the electrochemical reaction place where fuel oxidation reaction and oxidant reduction reaction take place. The electrode can be divided into two parts, one for the anode and the other for the cathode. The structure of the fuel cell is different from that of the ordinary battery plate electrode in that the fuel cell has a very porous structure. Current of high temperature fuel cell electrode mainly catalytic materials, for example, the solid oxide fuel cell Y2O3-stabilized-ZrO2 and nickel oxide electrode of molten carbonate fuel cell. The cryogenic fuel cell is mainly composed of a thin layer of catalyst material supported by the gas diffusion layer, such as platinum electrode of phosphoric acid fuel cell and proton exchange membrane fuel cell.

The main function of the electrolyte diaphragm is to separate oxidants from reducing agents and to conduct ions. Therefore, the thinner the better electrolyte diaphragm, but also need to take into account the strength. At this stage of the technology, its thickness is generally about a few millimeters to several hundred millimeters. As for material, at present basically two development directions, one is to make porous diaphragm with insulation material such as asbestos film, SiC film of SiC of silicon carbide, lithium aluminate film first, immerse again in melting lithium - potassium carbonate, potassium hydroxide and phosphoric acid wait, make its adherent in diaphragm hole. The other is the use of perfluorosulfonic acid resin and YSZ.

The collector, also known as bipolar plate, has the functions of collecting current, separating oxidant and reducing agent, and dredging reaction gas. The performance of the collector mainly depends on its material characteristics, flow field design and processing technology[3].

## 3. Classification of fuel cell

According to the type of electrolyte and fuel cell, it can be divided into five categories: basic fuel cell (AFC), phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC), solid hydrogenation fuel cell (SOFC), proton exchange membrane fuel cell (PEMFC). AFC, PEMFC and PAFC are low temperature fuel cells, MCFC and SOFC are high temperature fuel cells.

For AFC, it is necessary to solve the problems of electrolyte degradation, water and heat balance control; for PAFC, it is expected to break through in the development of cheap catalyst, prolonging system life and reducing cost; for MCFC, it is expected to increase working pressure, increase output current density, prolong battery life and reduce cost; for SOFC, it is expected to improve battery structure, develop heat-resistant materials and thin-film electrolyte; in practice Now it operates at low temperature[4].

## 4. Application of fuel cell

Fuel cells are currently used in many fields, such as aerospace, military, energy, transportation, and industrial fields.

In the field of aerospace, famous applications are hydrogen and oxygen engines. The eu's "CRYOPLANE" project, a new high-powered carrier rocket and powertrain fuel, has fully demonstrated the technical viability of liquid hydrogen as a future aviation fuel. Given that the same weight of liquid hydrogen has 218 times the energy density of kerosene, its impact on the future of aviation could be revolutionary. There are also electric aircraft powered by fuel cells powered by hydrogen.

In the military field, there are hydrogen-fueled fuel cell powered submarines, Quantum AMV "attacker" military vehicles, military locomotives, small and medium-sized fuel cell power plants for recharging ship batteries, etc.

In the energy field there are hydrogen fuel cells, solar - hydrogen systems, and biomass - hydrogen systems.

In the field of transportation, including fuel cell vehicles, buses, a variety of suitable vehicles including golf cars, engineering vehicles, forklifts, trucks, cranes, mining locomotives, bicycles, motorcycles, etc.

In the industrial field, hydrogen is an important chemical raw material, a reducing/protective gas for the metallurgical and semiconductor industries, and a fuel supply for the new plasma process, which plays an important role in the improvement of the new material preparation process.

At present, the utilization of hydrogen energy has penetrated into various fields in different degrees, which indicates the feasibility of further industrialization of hydrogen energy[5].

## 5. Challenges od fuel cell

However, there are some challenges facing fuel cells, and if we try to overcome them, it will be our opportunity.

The first challenge is that fuel cells and hydrogen are too expensive. The cost of hydrogen energy has always been high, but a surge in U.S. natural gas production has made hydrogen much cheaper. In addition, hydrogen can be synthesized into water by electrolysis. More importantly, hydrogen now costs less than gasoline. The researchers also found ways to make fuel cells using relatively inexpensive materials. When it comes to cost, at least for now, hydrogen batteries are competitive.

The second challenge is the difficulty of storing hydrogen. Hydrogen storage is challenging. Because hydrogen is a gas. As a result, hydrogen storage takes up a lot of space and requires large tanks with thick walls. This is a headache for hydrogen cars. Fortunately, many companies have successfully developed systems for commercial vehicles that transport hydrogen in the same way that ammonia does.

The third challenge is that the world is still focused on oil and the fuel hydrogen infrastructure is weak. In fact, the current hydrogen infrastructure is not very strong, but in many developed countries, you can still see natural gas and water infrastructure. Both can be used to produce hydrogen at a cost comparable to or slightly less than gasoline. This eliminates the need to ship hydrogen in a trailer or enables direct generation of hydrogen on site.

The spread of fuel cells has made them more executable in the past. Not only that, many places have started to implement it. Toyota and Mirai have had successful results, while Honda and hyundai are positioning themselves as hydrogen-fueled vehicles that they plan to compete with industry rivals. So fuel cell technology has a long way to go to reduce the use of fossil fuels as much as possible, but it aims to reduce emissions and solve the problem of energy depletion. The future of fuel cells is bright.

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