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A REVIEW ARTICLE ON FUEL CELL

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Abstract

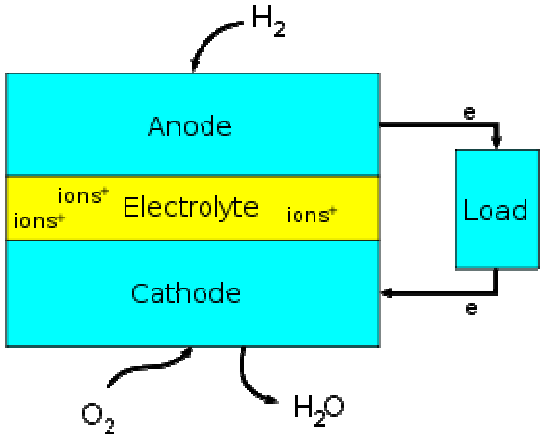
A fuel cell is a device that uses hydrogen (or hydrogen-rich fuel) and oxygen to create electricity by an electrochemical process. If pure hydrogen is used as a fuel, fuel cells emit only heat and water as a by-product. Several fuel cell types are under development, and they have a variety of potential applications. Fuel cells are being developed to power passenger vehicles, commercial buildings, homes, and even small devices such as laptop computers.

Keywords: Fuel Cell

1. Introduction Of Fuel Cells

In principle, a fuel cell operates like a battery. Unlike a battery, a fuel cell does not run down or require recharging. It will produce energy in the form of electricity and heat as long as fuel is supplied.

A fuel cell consists of two electrodes sandwiched around an electrolyte. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat. Hydrogen fuel is fed into the "anode" of the fuel cell. Oxygen (or air) enters the fuel cell through the cathode. Encouraged by a catalyst, the hydrogen atom splits into a proton and an electron, which take different paths to the cathode. The proton passes through the electrolyte. The electrons create a separate current that can be utilized before they return to the cathode, to be reunited with the hydrogen and oxygen in a molecule of water.



2. How Fuel Cells Work?

Fuel Cell Components & Function: A fuel cell is a device that uses hydrogen (or hydrogen-rich fuel) and oxygen to create electricity by an electrochemical process. A single fuel cell consists of an electrolyte sandwiched between two thin electrodes (a porous anode and cathode). While there are different fuel cell types, all work on the same principle: Hydrogen, or a hydrogen-rich fuel, is fed to the anode where a catalyst separates hydrogen's negatively charged electrons from positively charged ions (protons). At the cathode, oxygen combines with electrons and, in some cases, with species such as protons or water, resulting in water or hydroxide ions, respectively. For polymer exchange membrane (PEM) and phosphoric acid fuel cells, protons move through the electrolyte to the cathode to combine with oxygen and electrons, producing water and heat. For alkaline, molten carbonate, and solid oxide fuel cells, negative ions travel through the electrolyte to the anode where they combine with hydrogen to generate water and electrons. The electrons from the anode side of the cell cannot pass through the membrane to the positively charged cathode; they must travel around it via an electrical circuit to reach the other side of the cell. This movement of electrons is an electrical current. The amount of power produced by a fuel cell depends upon several factors, such as fuel cell type, cell size, the temperature at which it operates, and the pressure at which the gases are supplied to the cell. Still, a single fuel cell produces enough electricity for only the smallest applications. Therefore, individual fuel cells are typically combined in series into a fuel cell stack. A typical fuel cell stack may consist of hundreds of fuel cells. Direct hydrogen fuel cells produce pure water as the only emission. This water is typically released as water vapour. Fuel cells release less water vapour than internal combustion engines producing the same amount of power.

Pure Hydrogen

Most fuel cell systems are fuelled with pure hydrogen gas, which is stored onboard as a compressed gas. Since hydrogen gas has a low energy density, it is difficult to store enough hydrogen to generate the same amount of power as with conventional fuels such as gasoline. This is a significant problem for fuel cell vehicles, which need to have a driving range of 300-400 miles between refuelling to be competitive gasoline vehicles. High-pressure tanks and other technologies are being developed to allow larger amounts of hydrogen to be stored in tanks small enough for passenger cars and trucks. In addition to onboard storage problems, our current infrastructure for getting liquid fuel to consumers can't be used for gaseous hydrogen. New facilities and delivery systems must be built, which will require significant time and resources. Costs for large-scale deployment will be substantial.

Hydrogen-rich Fuels

Fuel cell systems can also be fuelled with hydrogen-rich fuels, such as methanol, natural gas, gasoline, or gratified coal. In many fuel cell systems, these fuels are passed through onboard "reformers" that extract hydrogen from the fuel. Onboard reforming has several

Advantages

There are also several disadvantages to reforming hydrogen-rich fuels: Onboard reformers add to the complexity, cost, and maintenance demands of fuel cell systems. High-temperature fuel cell systems can reform fuels within the fuel cell itself-a process called internal reforming-removing the need for onboard reformers and their associated costs. Internal reforming, however, does emit carbon dioxide, just like onboard reforming. In addition, impurities in the gaseous fuel can reduce cell efficiency.

Benefits of Fuel Cells

The current market for fuel cells is about $218 million and will rise to $2.4 billion by 2004, reaching $7 billion by 2009, according to studies by the Business Communications Company. The studies estimate the 2004 markets for fuel cells to break down as follows:
• $850 million - electric power generation
• $750 million - motor vehicles
• $200 million - portable electronic equipment
• $200 million - military/aerospace
• $400 million - other

Energy Security

Passenger vehicles alone consume 6 million barrels of oil every single day, equivalent to 85 percent of oil imports.
• If just 20 percent of cars used fuel cells, we could cut oil imports by 1.5 million barrels every day.
• If every new vehicle bought next year was equipped with a 60-kW fuel cell, we would double the amount of the country's available electricity supply.
• 10,000 fuel cell vehicles running on non-petroleum fuel would reduce oil consumption by 6.98 million gallons per year. One study forecasts that there will be millions of fuel cell vehicles on the road by 2010.* Fuel cell power will reach tens of thousands of vehicles by 2003 to 2004.
• ABI estimates that, by 2010, automotive fuel cells will have a nearly 4 percent market share - 608,000 vehicles.
• Market penetration in 2010 could rise as high as 1.2 million vehicles, representing 7.6 percent of the total U.S. new car market.

Fuel Cell Emissions

Fuel cells running on hydrogen derived from a renewable source will emit nothing but water vapour.

3. **Why Are Hydrogen & Fuel Cells Important?**

Widespread use of hydrogen as an energy source in this country could help address concerns about energy security, global climate change, and air quality. Fuel cells are an important enabling technology for the Hydrogen Future and have the potential to revolutionize the way we power our nation, offering cleaner, more-efficient

alternatives to the combustion of gasoline and other fossil fuels. These benefits are explained in more detail below.

Strengthen National Energy Security

Hydrogen and fuel cell technology have the potential to strengthen our national energy security by reducing our dependence on foreign oil. The U.S. uses about 20 million barrels of oil per day, at a cost of about $2 billion a week. Much of this is used to power highway vehicles. In fact, half of the oil used to produce the gasoline you put in your tank is imported. Hydrogen can be derived from a variety of domestically available primary sources, including fossil fuels, renewable, and nuclear power. This flexibility would make us less dependent upon oil from foreign countries.

Reduce Greenhouse Gas Emissions

Greenhouse gases are thought to be responsible for changes in global climate. They trap excess heat from the sun's infrared radiation that would otherwise escape into space, much like a greenhouse is used to trap heat. When we drive our cars, and light, heat, and cool our homes, we generate greenhouse gases. But if we used hydrogen in very high efficiency fuel cells for our transportation and to generate power, we could significantly reduce the GHG emissions - especially if the hydrogen is produced using renewable resources, nuclear power, or clean fossil technologies.

Reduce Air Pollution

The combustion of fossil fuels by electric power plants, vehicles, and other sources is responsible for most of the smog and harmful particulates in the air. Fuel cells powered by pure hydrogen emit no harmful pollutants. Fuel cells that use a reformer to convert fuels such as natural gas, methanol, or gasoline to hydrogen do emit small amounts of air pollutants such as carbon monoxide (CO), although it is much less than the amount produced by the combustion of fossil fuels.

Improve Energy Efficiency

Fuel cells are significantly more energy efficient than combustion-based power generation technologies. A conventional combustion-based power plant typically generates electricity at efficiencies of 33 to 35 percent, while fuel cell plants can generate electricity at efficiencies of up to 60 percent. When fuel cells are used to generate electricity and heat (co-generation), they can reach efficiencies of up to 85 percent. Internal-combustion engines in today's automobiles convert less than 30 percent of the energy in gasoline into power that moves the vehicle. Vehicles using electric motors powered by

hydrogen fuel cells are much more energy efficient, utilizing 40-60 percent of the fuel's energy. Even FCVs that reform hydrogen from gasoline can use about 40 percent of the energy in the fuel.

Applications for Fuel Cells

1.Stationary
2.Residential
3.Transportation
4.PortablePower

There are many uses for fuel cells - right now, all of the major automakers are working to commercialize a fuel cell car. Fuel cells are powering buses, boats, trains, planes, scooters, even bicycles. There are fuel cell-powered vending machines, vacuum cleaners and highway road signs. Miniature fuel cells for cellular phones, laptop computers and portable electronics are on their way to market. Hospitals, credit card centres, police stations, and banks are all using fuel cells to provide power to their facilities. Wastewater treatment plants and landfills are using fuel cells to convert the methane gas they produce into electricity. The possibilities are endless.

Stationary. More than 200 fuel cell systems have been installed all over the world - in hospitals, nursing homes, hotels, office buildings, schools, utility power plants, and an airport terminal, providing primary power or backup. In large-scale building systems, fuel cells can reduce facility energy service costs by 20% to 40% over conventional energy service.

Residential. Fuel cells are ideal for power generation, either connected to the electric grid to provide supplemental power and backup assurance for critical areas, or installed as a grid-independent generator for on-site service in areas that are inaccessible by power lines. Since fuel cells operate silently, they reduce noise pollution as well as air pollution and the waste heat from a fuel cell can be used to provide hot water or space heating for a home. Many of the prototypes being tested and demonstrated for residential use extract hydrogen from propane or natural gas.

Transportation. All the major automotive manufacturers have a fuel cell vehicle either in development or in testing right now - Honda, Toyota, DaimlerChrysler, GM, Ford, Hyundai, Volkswagen - you name it. They speculate that the fuel cell vehicle will not be commercialized until at least 2004. For more information on fuel cells in transportation checkout our

Portable Power. Miniature fuel cells, once available to the commercial market, will help

consumers talk for up to a month on a cellular phone without recharging. Fuel cells will change the telecommuting world, powering laptops and palm pilots hours longer than batteries. Other applications for micro fuel cells include pagers, video recorders, portable power tools, and low power remote devices such as hearing aids, smoke detectors, burglar alarms, hotel locks and meter readers. These miniature fuel cells generally run on methanol, an inexpensive wood alcohol also used in windshield wiper fluid.
Fuel cells can be used to power a variety of portable devices, from handheld electronics such as cell phones and radios to larger equipment such as portable generators. Other potential applications include laptop computers, personal digital assistants (PDAs), and handheld video cameras-almost any application that has traditionally used batteries. These fuel cells have the potential to last more than three times as long as batteries between refuelling. In addition to these smaller applications, fuel cells can be used in portable generators, such as those used to provide electricity for portable equipment. It is estimated that about 1,700 portable fuel cell systems have been developed and operated worldwide, ranging from 1 watt to 1.5 kilowatts in power. The two primary technologies for portable applications are polymer electrolyte membrane (PEM) and direct methanol fuel cell (DMFC) designs. Most portable, fuel-cell-powered products are still in the development and demonstration stages. However, a handful of devices, such as portable power generators, are available commercially on a very limited basis.

4. Conclusion

Fuel cells are being developed to power passenger vehicles, commercial buildings, homes, and even small devices such as laptop computers. Fuel cells have several benefits over conventional combustion-based technologies currently used in many power plants and passenger vehicles. They produce much smaller quantities of greenhouse gases that contribute to global warming and none of the air pollutants that create smog and cause health problems. In fact, if pure hydrogen is used as a fuel, only heat and water are emitted. Fuel cells are more efficient than combustion-based technologies, and the hydrogen used to power them can be obtained from a variety of sources, including fossil fuels, renewable sources, and nuclear energy. Since the fuel can be produced from domestically available resources, fuel cells have the potential to improve national energy security by reducing our dependence on oil from foreign countries. Although the potential benefits of fuel cells are significant, many challenges, technical and otherwise, must be overcome before fuel cells will be a successful, competitive alternative for consumers. These include cost,

durability, fuel storage and delivery issues, and public acceptance.

5. References

1. International Energy Agency. "World Energy Outlook 2006". Pp 71-78
2. C. Y. Wang "Fundamental models for full cell engineering". Chemical Review, 104: 4727-4765, 2004.
3. J. B. Young. "Thermofluid modelling of fuel cells". Annual Review of Fluid Mechanics, 39: 193-215.
4. A. Biyikoglu. "Review of proton exchange membrane full cell models". International Journal of Hydrogen Energy, 30: 1181-1212: 2005'
5. S. C. Singhal. "Solid Oxide fuel cell for stationary, mobile and military applications". Solid State Ionics, 152-153: 405-410, 2002.
6. M. C. Williams, J. P. Strakey, W. A. Surdoval L. C. Wilson."Solid oxide fuel cell technology development in the U.S.". Solid State Ionics, 177: 2039-2044, 2006.
7. M. Dokiya. "SOFC system and technology". Solid State Ion, 152-153: 383-392, 2002.
8. P. Iora, S. Campanari. "Development of a three-dimensional molten carbonate fuel cell model and application hybrid cycle simulations". Journal of Fuel Cell Science and Technology, 4: 501-510, 2007.