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ALTERNATIVE FUEL FOR FUEL CELL POWERED VEHICLES

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ABSTRACT

In response to the ever-growing concerns for environmental protection, the development of cleaner, more energy efficient, environmentally friendly vehicle while maintaining vehicles performance, comfort & safety. For more than 60 years automobile industries has working for an various alternative power source vehicles & has place varieties of vehicles on the road, Though the most challenging task for automobile scientists is to provide a pollution free vehicle. But the situations become a worldwide phenomenon so there is need to go alternative fuels for automobiles.

To overcome above problem fuel cell vehicle (FCV) is the best. It achieves twice the efficiency & near a zero emission with the only by product being pure water. The PEM fuel cell proposed for future vehicles, hydrogen as a fuel supplying hydrogen gas or hydrogen–rich reformer is critical issue. A large no. of fuel source can be used to provide the hydrogen, each has benefits & limitations.

This paper will explore the alternative fuel cell issue, fuel cell; it's working, & highlighting the advantages, disadvantages of hydrogen, methanol reformer, hydrocarbon (gasoline) reformer and FCVs.

INTRODUCTION

The inventor of fuel cell technology is Sir William Grove in the 1830s in london he demonstrated about a hydrogen fuel cell. Grove's technology remained without a practical application for 100 years. Fuel cells returned to the laboratory in the 1950s space program required the development of new power systems in united states.

Today, the fuel cells are required to overcome from the different technologies, technical issues, and market dynamics that make for a complex but at the final it become as an excellent output with better result. Significant amounts of public and private investment and are being used for fuel cell products requires in all the automobiles applications.

Fuel cells are electrochemical devices converts chemical energy to electrical energy without combustion. Fuel cells can operate using various fuels. When hydrogen and oxygen are used as the primary

Fuels for the chemical reaction, the bi-products of electrical production are Heat and pure water (H2O) .

Hydrogen (H2) is the most abundant element in the universe and to be utilized by fuel cells. Getting hydrogen is more complicated, even though it, too, is all around us. A fuel cell produces electricity from oxygen and hydrogen. Hydrogen is the available element on Earth, but before it can be used in fuel cells it must first be derived from water or hydrocarbons such as gasoline, propane, natural gas, and methanol. Oxygen is obtained from the air.

Supplying hydrogen as either hydrogen gas or a hydrogen-rich reformate is a critical issue. A huge amount of fuel options for fuel cells can be used to provide hydrogen, each has advantages and disadvantages. In this paper we explore the fuel choice issues, methanol reformer, hydrocarbon (gasoline) reformers, system complexity and feasibility.

FUEL CELLS

In response to the ever growing concern for environmental protection, the development of cleaner, more energy efficient, environmentally friendly energy system developed without scarifying performance comfort and safety. Following goals are satisfied by fuel cells, the disadvantages are hydrogen storage safety and high cost.

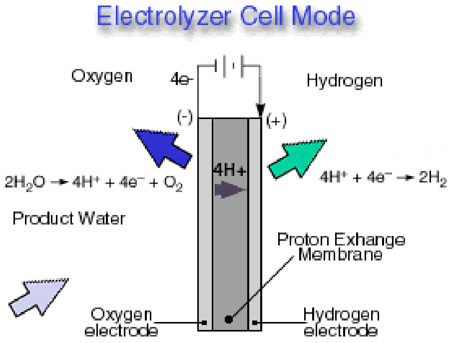
- Improving energy efficiency.
- Promoting clean energy technologies.
- .Ensuring reliability
- Avoiding sound pollution.
- Low emissions.
- Expanding energy choices.

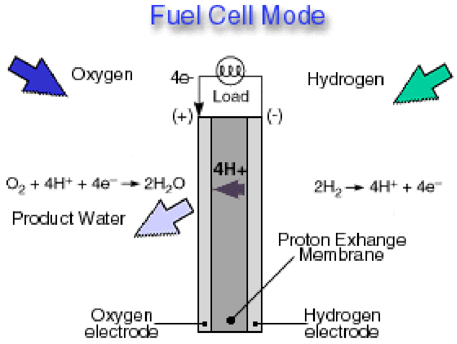
Fuel Cell

A fuel cell is an energy conversion device that electrochemically converts chemical energy to electrical energy with the help of hydrogen and oxygen as reactants and producing water as the only by-product.

Basic components

Each fuel cell system consists of three primary subsystems: 1) the fuel cell stack that generates direct current electricity; 2) the processor of fuel that converts the natural gas into a hydrogen rich feed stream; and 3) the conditioner of power that converts the electric energy into alternating current or regulated direct current.





Fuel cell principle

Anode (hydrogen side)

In a first step, molecular hydrogen H2 is split in 2 hydrogen ions H+ and 2 electrons e- under catalytic influence (e.g. Platinum).

Reaction equation anode:

2 H2 -> 4 H+ + 4 e-

Electrolyte (membrane)

In an PEM fuel cell electrolyte is conductive only for protons, therefore the positively charged H+ ions pass thru the membrane from the anode to the cathode. The -vely charged electrons have to travel thru the external load by providing electrical power.

Cathode (oxygen side)

cathode reaction is much more complex. In principle a oxygen molecule O_2 from the surrounding air reacts with 2 H^+ ions to H_2O_2 by consuming 2 electrons e^-. In a second step H_2O_2 reacts to 2 H20 (water) molecules by consuming another 2 H^+ ions and 2 electrons e^- .

Simplified cathode reaction equation:
$O_2 + 4 H^+ + 4 e^- \rightarrow 2 H_2O$

At cathode it has a lack of electrons while in anode we have a surplus on electrons. If anode and cathode are electrically connected, an electrons passes from anode to cathode to balance this difference in electrical charge. current flows as long as the reaction continues or in other words as long as hydrogen and oxygen is available to the cathode/anode of a fuel cell. This circuit is connected with the electrical load makes it possible to utilize the so generated electrical power.

The fuel cell with theoretical open circuit obtained is 1,229V, in real applications it is possible to achieve app. 1,05V operating with pure oxygen and app. 0,95V operating with air. To achieve higher voltage levels, It is often desired to drive standard loads, Lots of many single fuel cells are connected together in series to a fuel cell stack.

The overall efficiency is app. 60%, while combustion engines operate at app. 35% (Carnot diagram). The energy that a fuel cell generates its energy as electrical power and heat. Dependant of the actual load conditions of the split of heat changes and electrical power. The high efficiency, the generation of electrical power is direct and the low to zero emissions make the fuel cell a superior technology. Fuel cell is a reversal of the water electrolysis, where water is split into hydrogen and oxygen by supplying electrical power. The following reactions occur at the anode and cathode of a PEM fuel cell.

HYDROGEN FROM LIQUID FUELS

The catalytic conversion of fuels to hydrogen can be carried out by three major techniques:

1. Steam reforming
2. Partial oxidation and
3. Auto thermal reforming

Steam reforming

Steam reforming (SR) is considered the most common technique for hydrogen production. It is based on the combination of the fuel with steam to produce carbon di oxide and hydrogen. Typical stoichiometry for iso-octane and methanol are shown below.

$C_8H_{18} + 8H_2O + 1.28*103\ KJ/mol = 8CO_2 + 17H_2$
$CH_3OH + H_2O + 122\ KJ/mol = CO_2 + 3H_2$

The main stream reforming reactions are strongly endothermic and reactor design is usually limited by heat transfer. As a result, the reactors are designed to improve the heat transfer and usually bulky.

Partial oxidation

The partial oxidation (POX) refers to the reaction of the fuel with air to produce hydrogen and carbon oxides. This approach generally uses air as oxidant, and results in a reformate which is diluted with nitrogen. It requires subsequent water gas shift reacters to capture more hydrogen from H_2O by conversion of CO to CO_2. The main reaction is exothermic which is advantageous.Typical stichiometry for iso-octane (a typical gasoline molecule) is shown below.
$C_8H_{18} + 4O_2 + 16N_2 = 8CO + 9H_2 + 659\ KJ/mol$

Auto thermal reforming Typical stichiometry for iso-octane (a typical gasoline molecule) is shown below. $C_8H_{18} + 4O_2 + 16N_2 = 8CO + 9H_2 + 659\ KJ/mol$

Auto thermal reforming

The auto thermal reformers combine the heat effects of partial oxidation and steam reforming and oxidation. Fuel, air and steam are passed to a reactor; the steam reforming reactions absorb the heat generated by decreasing in operating temperature and partial oxidation.

The stichiometry for iso-octane is shown below.
$C_8H_{18} + 2.64O_2 + 9.9N_2 + 2.72H_2O = 8CO + 11.7\ H_2O + 9.9N_2$ (no net heat input /production)

Auto thermal reforming produces more concentrated hydrogen reformate than straight POX, though less concentrated than pure steam reforming. ATR offers the most flexibility in heat management and thus potential higher efficiency than POX with better transient response than SR.

In general any of the fuel considered as hydrogen carries (e.g. gasoline, methanol, ethanol, LPG) can be used in any of the three reformer designs. Differences in chemical the nature of the fuels, however can favor one design over another.

ONBOARD HYDROGEN GENERATION

Onboard fuel processors convert hydrocarbons into hydrogen rich gas products, called reformate. The two leading candidates for onboard fuel processing are
1) Methanol fuel processor
2) Gasoline fuel processor

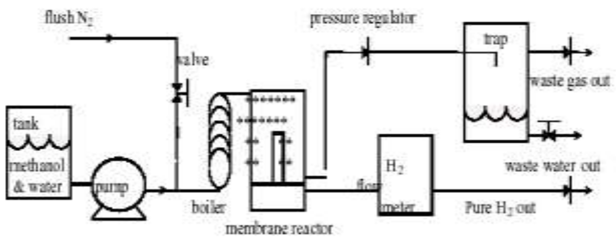
4.1. Methanol fuel processor

Operating Principle

The methanol reformer produces hydrogen by methanol reforming and water in a membrane reactor, a unique type of reactor that purifies and hydrogen is produced. Plug into a standard 120 V outlet to power the pump control monitoring equipment, and mixture of laboratory is fill with 2:1 methanol and distilled deionized water. The pump compresses the methanol-water mixture to 200 psi and pumps it to the boiler in order to vaporize it. The gas mixture then goes into the reactor and converted to hydrogen gas and gas by-products and a small amount of left-over water. The excess water is there to keep the catalyst from 'coking'.

The membrane separates as the reaction continues out the resulting ultra pure hydrogen, which is available for use in other applications and fuel cells . The waste gas and waste water goes to a liquid it will trap and exits the system. Before shut down,it will flush with 200 psi nitrogen. The methanol-water feed rate can be adjusted at the pump. Due to reactor design, the hydrogen delivery pressure and flow rate adjusts itself to follow a changing load.

Flow Diagram



Advantages

- It is the simplest of the three primary reformer designs.
- Methanol reformer systems do not require much additional equipments to remove excess heat.
- It produces highly concentrated hydrogen with steam as oxidant.
- The low temperature produces nearly zero nitrogen oxide(NOX) emissions

- It offers potential for lowest cost and smallest size.

Limitations

- Heat required to vaporize methanol is high (4 times that of gasoline)
- Long start up time about 30 minutes.
- It does not offer any fuel flexibility(only methanol can be processed)
- Most impurities organic or inorganic (e.g. salts) are poisons to the catalyst system.

4.2. Gasoline fuel processor

POX and ATR are the leading designs for conversion of gasoline in a fuel cell vehicle.they are also the leading designs for conversion of other hydrocarbon and from the alcohol fuel sources like ethanol and methane.POX reactors generally run at high temperature typically nearer to 800 to 1000 c and produce carbon monoxide (syngas) and hydrogen . The condition in the POX reactor, while much hotter than the methanol SR, do not produce significant amount of NOX from the nitrogen in the air.Syngas generation technology is widely participated on an industrial scale for several processes. It is the key step in synthetic fuel production.

Advantages

- Due to exothermic nature of gasoline POX system much faster start-up of the primary reformer is possible.
- Highly flexible for fuels like methane, LPG, napthane, ethanol, ethanol and even kerosene or jet fuel.
- Less sensitive to impurities.
- Liquid fuels like gasoline have a much higher hydrogen density than methanol.

Limitations

- Require additional process steps, most likely water gas shift reactor.
- Design is complicated due to high temperature exothermic reaction.
- Gasoline contains small amount of sulphur, a poison to fuel cell stack.

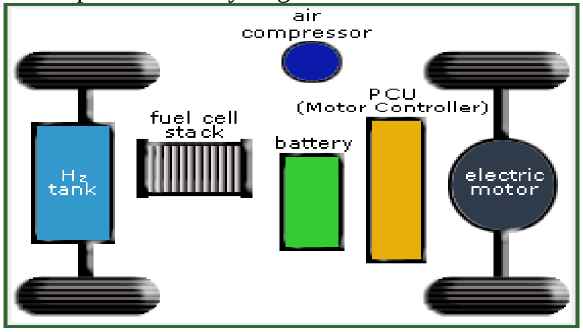
FUEL CELL VEHICLE

FCVs represent a radical departure from vehicles with conventional internal combustion engines. Like electric vehicles,motors are used to propell FCVs. But while battery electric vehicles use electricity from an external source and it is stored in the battery, FCVs create their own electricity. Fuel cells onboard the vehicle through a chemical process it creates electricity by using hydrogen fuel and oxygen from the air. FCVs can be fueled with pure hydrogen gas are stored in high-pressure tanks. They also can be fueled with hydrogen-rich fuels; Like gasoline, natural gas,methanol, but these fuels must first be converted into hydrogen gas.

FCVs can be twice as efficient when compared to the conventional vehicles. They can also be equipped with other advanced technologies to increase efficiency, such The energy lost is absorbed by regenerative braking during braking and store it in an upsized battery.

Components

The below figure shows the basic components of a hydrogen-fueled FCV.



- **H2 tank**: FCV's use pure h2 generally store it as gas in high pressure tank. Current FCV can store H2 as 5000 lb/in2.
- **Fuel cell stack**: which contains more than 400 fuel cell stacks uses, hydrogen and air to produce electricity
- **Battery**: FCV use battery to store electricity which can help to power the electric motor or other electrical devices.
- **(PCU) Motor controller**: It manages electricity production and storage.
- **Electric motor**: FCV powered by one or several motors. Generally AC Induction or DC Brushless motors are used.
- **Air compressor**: The amount of electricity generated depends on fuel supply .the air compressor controls the rate at which air is supplied to fuel cell stacks.

REFUELLING A FUEL CELL VEHICLE

FCVs can be fueled with pure hydrogen gas stored directly on the vehicle in tanks or extracted from a secondary fuel, like methanol, ethanol, or natural gas that carries oxygen. These secondary fuels are converted into hydrogen gas using onboard device called a reformer. FCVs fueled with pure hydrogen emit no pollutants—only water and heat. FCV that use secondary fuels and a reformer produce only small amounts of air pollutants.

BENEFITS

- FCVs fueled with pure hydrogen no pollutants are emitted by it; only water and heat.
- FCVs are twice as efficient than conventional vehicles
- This FCV has reduce harmful emissions and energy use.
- No greenhouse gases and Reduced CO2 emissions
- Design flexibility to accommodate any body shape as per requirement and space constraints.
- Quitter operation.
- Potential for a new vehicle concept.

CONCLUSION

The choice of a fuel to power the fuel cell vehicle of tomorrow is critical, and a large no of factors must be weighed. FCVs must compete with other emerging technologies and be competitive on cost and performance. Hydrogen, while an ideal fuel for the fuel cell stack, currently has disadvantages as a transportation fuel.

Methanol and gasoline have both advantages and disadvantages as source of hydrogen for fuel cells, and both should continue to be developed before a commercialization choice is made. Production prototypes running standardized driving cycles, and true well- to- wheel analysis will determine which the best Overall choice is. It is needed to consider not simply the fuel processor technology, but safety and health consideration, overall infrastructure costs, fuel cost on a tax neutral basis, and acceptance by the public of new technologies.

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