ENVIRONMENT-FRIENDLY HYDROGEN GAS AS FUEL IN FUEL CELL AND ITS CHALLENGES

Hydrogen is the simplest and lightest element. Storage is one of the greatest problems for hydrogen. It leaks very easily from container meant for storage, no mater how strong and no matter how well insulated. Therefore, hydrogen in storage tanks always evaporates, at a rate of at least 1.7 percent per day.

Another important property of hydrogen is it is very reactive in nature. When hydrogen gas comes into contact with metal surfaces it decomposes into hydrogen atoms, which are so very small that they can penetrate metal. This causes structural changes that make the metal brittle.

One of the largest problems perhaps hydrogen fuel cell transportation has is its fuel tank size. In gaseous form of hydrogen, a volume of 238,000 litres gas is necessary to replace the same energy capacity of 20 gallons of petrol (gasoline). One option is to compress the gas. Because of gas's low density property, compressed gas does not give a car as useful a as of gasoline as far as storage volume is concerned. Moreover, a compressed hydrogen fuel tank would be at risk of developing pressure leaks either through accidents or through normal wear and such leaks could result in dangerous explosions.

In case, the hydrogen is liquefied, the liquid hydrogen would give a density of 0.07 grams per cubic centimeter. In that case, it may require almost the four times volume of gasoline for a given amount of energy release. Besides, there are many difficulties in storing liquid hydrogen. Liquid hydrogen is cold enough to freeze air. Accidents may occur from pressure build-ups resulting from plugged valves. Besides, energy costs of liquefying the gas and refrigerating it also to be considered while calculating economy.

Other option may be considered is the use of powdered metals to store the hydrogen in the form of metal hydrides. The volume of stored metal hydrides would be little more than that of the metals themselves; but storing in this form, hydrogen would be far less reactive. However, the weight of the metals will make the storage tank very heavy.

As far as production of hydrogen is concerned, hydrogen does not freely occur in nature in useful quantities. Therefore hydrogen must be split from molecules, either molecules of methane derived from fossil fuels or from water. Currently, most hydrogen is produced by the treatment of methane with steam (the equation is CH4 (g) + H2O + e > 3H2(g) + CO(g)). The CO(g) in this equation is carbon monoxide gas, which is a byproduct of the reaction. Again the production of CO, which converts into CO2 is a greenhouse gas – not environment friendly option. Again, at present we do not have viable technology to obtain hydrogen from water, other than electrolysis – which is not energy saving option.

Therefore, as of now, it is a challenge before us to use hydrogen economically, efficiently and environment-friendly way. As lot research activities are going on in this field, very soon positive favorable result could be seen.

Principle of Hydrogen fuel cell:

The hydrogen fuel cell is an electrochemical energy conversion device. Hydrogen and oxygen are fed into opposite sides of a cell, which are separated by a membrane permeable to hydrogen ions but not electrons. Hydrogen gas molecules entering the anode side of the cell are ionized in the presence of a catalyst to form protons and electrons. The protons pass through the membrane to combine with the oxygen and electrons to produce water at the cathode. The electrons flow through an external circuit from the anode to the cathode, creating an electrical current, which powers an electric load such as a motor.

F. Environment-friendly Hydrogen Fuel Cell, its challenges and its efficiency:

Fuel cell is an electrochemical energy conversion device, wherein the electricity is directly produced by chemical reaction of fuel and an oxidizer. A fuel cell does not require recharging. The supply of fuel and oxidizer are to be continued as long as it is in operation. A fuel cell essentially consists of an anode—to which fuel such as hydrogen, ammonia etc., is supplied—and a cathode—to which an oxidant, commonly air or oxygen, is supplied. The two electrodes of a fuel cell are separated by a membrane of ionic conductor electrolyte.

fuelcell

A fuel cell is very similar to a battery in that it makes use of the energy stored in chemical substances. However, unlike the battery, in the fuel cell both the high-energy reactants and the low-energy products are not stored inside the cell. The reactants are supplied from outside the cell continuously and the products are removed from it once formed.

Probably the best-known type of fuel cell is hydrogen fuel cell that used in spacecraft. These cells react hydrogen and oxygen, forming water as they do so. The energy transferred from the hydrogen and oxygen in this process is collected as electrical energy rather than as heat. Fuel cells are compact and clean; the water produced by the fuel cells on the space laboratory used for drinking and washing purposes.

The hydrogen fuel cell is structured like a sandwich. At its core is a thin plastic foil – the proton exchange membrane (PEM), which is coated on both sides with a thin catalyst layer, preferably platinum (Pt), and a gas/permeable electrode out of a graphite paper. In the outer layers, gas channels have been milled into the two so-called bipolar flow field plates (FFP). Hydrogen flows through the channels on one side, while oxygen through those on the other side. Upon contact of the hydrogen with the Pt-catalyst, it causes the H-atom to ionize (to decompose into a proton H+ and an electron, e-). The positively charged protons permeate through the PEM membrane whereas the negative electrons do not. As a result of this diffusion process a voltage difference between the two electrodes out of graphite paper ensues. Attaching electrodes to the oppositely situated PME layers and connecting them via an external electrical load, the electrical gradient causing the electrons to flow through it, drive this load (e.g. DC motor). While the electrons are externally routed to the other side of the PME membrane, they join the oxygen, giving it a negative charge and finally merge with the protons that migrated directly through the foil. As a result of this electrochemical reaction, pure water (H2O) and a small amount of heat are formed.

Hydrogen and fuel cells have the potential to solve several major challenges facing the world today, i.e., increasing dependence on petroleum, poor air quality, greenhouse gas emissions and global warming. Many of the research programs are working the ways to accelerate the development and successful market introduction of these new exciting technologies.

Now the key challenges for commercialization of fuel cell and hydrogen infrastructure technologies include

(a) Fuel Cell Cost and Durability,

(b) Hydrogen Storage,

(c) Hydrogen Production and Delivery.

(d) Public Acceptance.

The efficiency of a fuel is dependent on the amount of power drawn from it. Drawing more power means drawing more current, which increases the losses in the fuel cell. As a general rule, the more power (current) drawn, the lower the efficiency. Most losses manifest themselves as a voltage drop in the cell, so the efficiency of a cell is almost proportional to its voltage. For this reason, it is common to show graphs of voltage versus current (so-called polarization curves) for fuel cells. A typical cell running at 0.7 V has an efficiency of about 50%, meaning that 50% of the energy content of the hydrogen is converted into electrical energy; the remaining 50% will be converted into heat. (Depending on the fuel cell system design, some fuel might leave the system unreacted, constituting an additional loss.)

For a hydrogen cell operating at standard conditions with no reactant leaks, the efficiency is equal to the cell voltage divided by 1.48 V, based on the enthalpy, or heating value, of the reaction. For the same cell, the second law efficiency is equal to cell voltage divided by 1.23 V. (This voltage varies with fuel used, and quality and temperature of the cell.) The difference between these number represents the difference between the reaction's enthalpy and Gibbs free energy. This difference always appears as heat, along with any losses in electrical conversion efficiency.

Fuel cells are not constrained by the maximum Carnot cycle efficiency as combustion engines are, because they do not operate with a thermal cycle. At times, this is misrepresented when fuel cells are stated to be exempt from the laws of thermodynamics. Instead, it can be described that the "limitations imposed by the second law of thermodynamics on the operation of fuel cells are much less severe than the limitations imposed on conventional energy conversion systems". Consequently, they can have very high efficiencies in converting chemical energy to electrical energy, especially when they are operated at low power density, and using pure hydrogen and oxygen as reactants.

In practice, for a fuel cell operated on air (rather than bottled oxygen), losses due to the air supply system must also be taken into account. This refers to the pressurization of the air and adding moisture to it. This reduces the efficiency significantly and brings it near to the efficiency of a compression ignition engine. Furthermore fuel cells have lower efficiencies at higher loads.

It is also important to take losses due to production, transportation, and storage into account. Fuel cell vehicles running on compressed hydrogen may have a power-plant-to-wheel efficiency of 22% if the hydrogen is stored as high-pressure gas, and 17% if it is stored as liquid hydrogen. Moreover, Fuel cells cannot store energy like a battery, but in some applications, such as stand-alone power plants based on discontinuous sources such as solar or wind power, they are combined with electrolyzers and storage systems to form an energy storage system. The overall efficiency (electricity to hydrogen and back to electricity) of such plants is between 30 and 50%, depending on conditions. While a much cheaper lead-acid battery might return about 90%, the electrolyzer/fuel cell system can store indefinite quantities of hydrogen, and is therefore better suited for long-term storage.

Source : http://saferenvironment.wordpress.com/2008/12/11/pollution-from-motor-vehicles-urgency-of-development-of-environment-friendly-cleaner-system-for-road-transport/