CAI335 SOLAR AND WIND ENERGY SYSTEM

UNIT V NOTES

5.6 Fuel Cell

A fuel cell is an electrochemical device in which the chemical energy of a conventional fuel is converted directly and efficiently into low voltage, direct current electrical energy.

Fuel cell systems generally operate on pure hydrogen and air to produce electricity.

One of the chief advantages of such a device in that because the conversion, at least in theory, can be carried out isothermally, the Carnot limitation on efficiency does not apply. The essential difference between the primary/secondary cell and fuel cell is of continuous energy input and output of fuel cell. A fuel cell system requires continuous supply of a fuel and an oxidizer and generates D.C. electric power continuously.

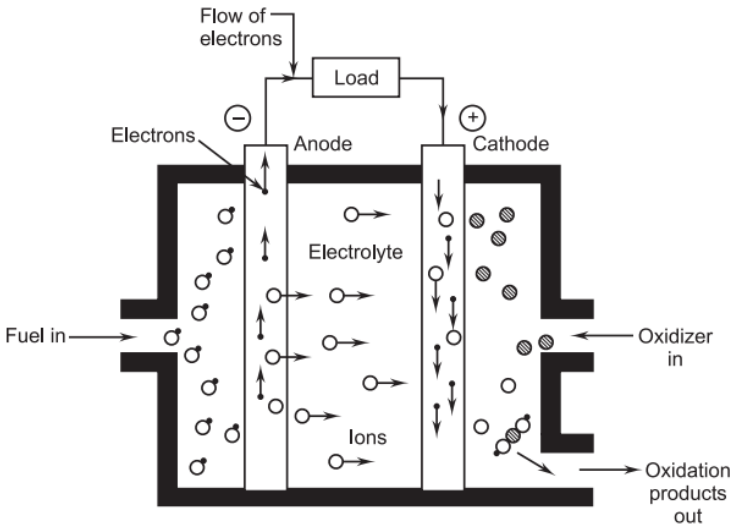
A battery has stored electrochemical energy within its container. After discharge it needs recharging or replacement. Fuel cells do not need such recharging replacement. A fuel cell is often described as a primary battery in which the fuel and oxidize are stored external to the battery and fed to it as needed.

Fuel cells can be manufactured as large or as small as necessary for the particular power application. Presently, there are fuel cells that are the size of a pencil eraser and generate few milliwatts of power while there are others large enough to provide large amount of power. The power output of fuel cells is fully scalable by varying the cross-sectional area of each cell to get desired current and by stacking multiple cells in series to obtain the desired voltage.

5.6.1 Components and Working Theory of a Fuel Cell

Components.

The main components of a cell are: 1. Anode (Fuel electrode) 2. Cathode (oxidant electrode) 3. Electrolyte 4. Container 5. Separators 6. Sealings 7. Fuel supply 8. Oxidizer



Working theory:

The 'fuel gas' diffuses through the anode and is oxidized, thus releasing electrons to the external circuit. The 'oxidizer' diffuses through the cathode and is reduced by the electrons that have come from the anode by way of the external circuit.

Of the available fuels, hydrogen has so far given the most promising results, although cells consuming coal, oil or natural gas would be economically much more useful for large scale applications.

Some of the possible reactions are:

Hydrogen/oxygen	1.23 V	$2H_2 + O_2 \longrightarrow 2H_2O$
Hydrazine	1.56 V	$N_2H_4 + O_2 \longrightarrow 2H_2O + N_2$

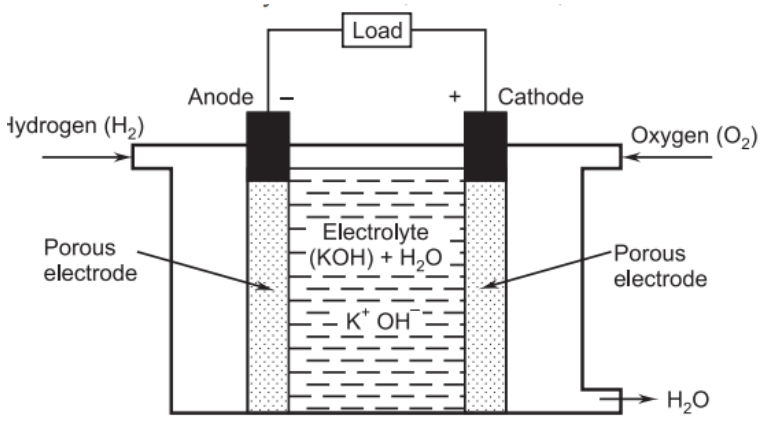
5.6.2 Desirable Characteristics of a Fuel Cell

The fuel cell should have the following characteristics: 1. It should have high energy conversion efficiency. 2. It should produce low chemical pollution. 3. It should be flexible to choose any fuel. 4. It should have cogeneration capability and rapid load response.

5.6.3 Types of Fuel Cell

Hydrogen-Oxygen Fuel Cell (Hydrox Cell)-Alkaline Fuel Cell (AFC)

In this cell hydrogen and oxygen are used as the ‘fuel‘ and ‘oxidant‘ respectively as these elements are most reactive with least complications. The ‘electrolyte‘ is potassium hydroxide (20 to 40% concentration) which has high electrical conductivity and is less corrosive than acids.



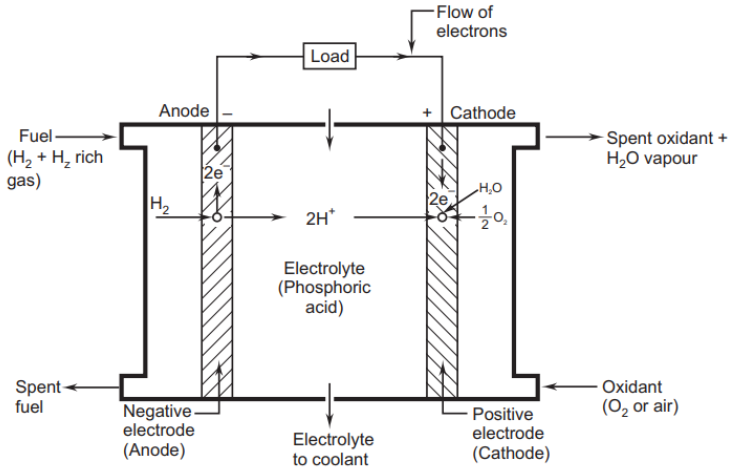
Construction.

It has three chambers separated by two porous nickel electrodes, the anode and cathode. The middle chamber between the electrodes is filled with a strong solution of potassium hydroxide (KOH). The surfaces of the electrodes are chemically treated to repel the electrolyte, so that there is minimum leakage of potassium hydroxide into the outer chamber.

Working

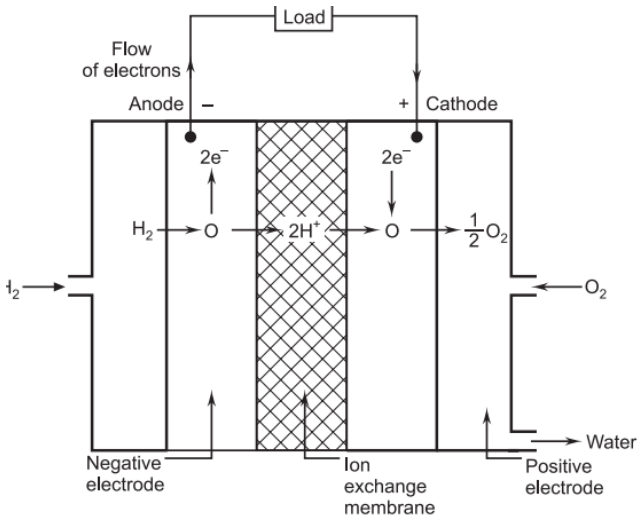
The electrolyte provides the (OH)– ions needed for the reaction, and remains unchanged at the end, since these are regenerated. The electrons liberated at the anode find their way to the cathode through the external circuit. This transfer is equivalent to the flow of current from the cathode to anode.

Phosphoric Acid Fuel Cell



The phosphoric acid cell consists of two electrodes of porous conducting material (e.g. nickel) to collect charge and, ‘phosphoric acid’ used as electrolyte. At anode, hydrogen molecule is split into hydrogen ions (protons) and electrons. The electrons flow through external circuit and produce electric power while protons travel through electrolyte and combine with oxygen, usually from air, at the cathode to form water. The electrochemical reaction is very slow, so a catalyst is required in the electrode to accelerate the reaction. The catalysts used are platinum, nickel (for anode) and silver (for cathode). Platinum is the best catalyst for both electrodes.

Polymer Electrolyte Membrane Fuel Cell (PEMFC)



In PEMFC cell, electrolyte is a solid polymer membrane of an organic material such as polystyrene sulphonic acid and this is permeable to protons (H+) when it is saturated with water but it does not conduct electrons. The fuel is hydrogen and charge carriers are hydrogen ions (protons). At the anode, the hydrogen molecule is split into hydrogen ions and electrons. The hydrogen ions permeate across the electrolyte to cathode while the electrons flow through an external circuit and produce electric power. Oxygen is supplied to the cathode and combines with electrons and hydrogen ions to produce water