Fuel Cells

A fuel cell is defined as an electrochemical device that continuously converts the chemical energy of fuel into electricity and heat without combustion

or

A cell (or combination of cells) capable of generating an electric current by converting the chemical energy of a fuel directly into electrical energy.

The fuel cell is similar to other electric cells in the respect that it consists of positive and negative electrodes with an electrolyte between them.

Fuel cell provides continuous energy input and output while the battery stores the electric charge.

Advantages of fuel cells over Conventional Power Plants:→

(1) It has very high conversion efficiencies as high as 70%.

(2) Fuel cells can be installed near the use point.

(3) It is quite in operation and less pollution

(4) There is no requirment for large volumes of cooling water

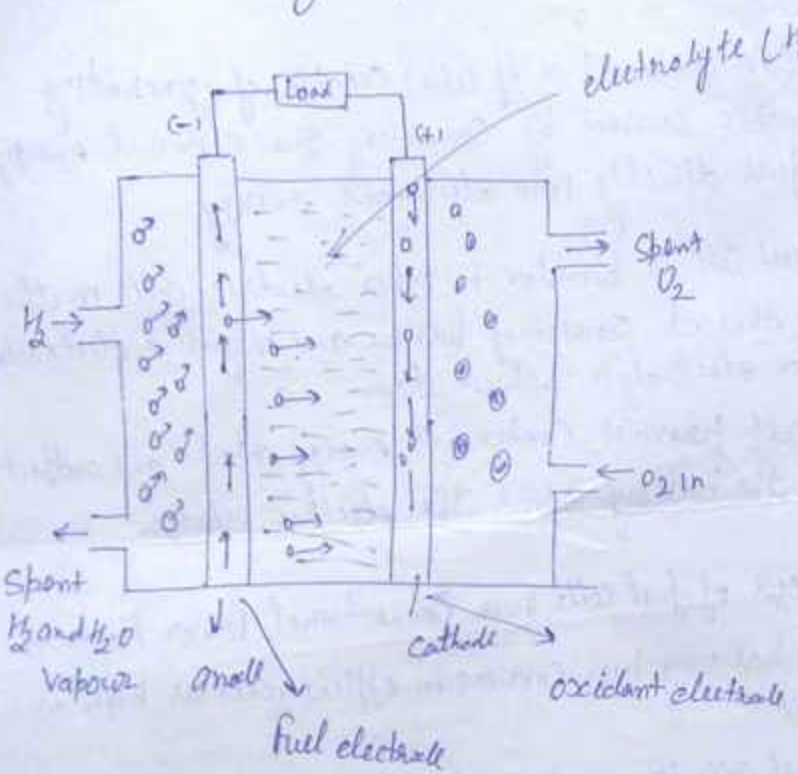
(5) Fuel cells do not make noise. they can be readily accepted in residential area.

(6) By use of Series-parallel combination of fuel cells, the output power rating at any voltage and current can be obtained

(7) The Capacity can be increased as the demand grows.

(8) Space requirement is much less

(9) It has long life



Molten Carbonate Fuel Cell (MCFC):-

A schematic diagram of a molten carbon fuel cell as shown in fig it is high temp fuel cell. The fuel, oxidant, electrodes and the electrolyte used are as follow

Fuel: Mixture of H_2 and CO

Oxidant: O_2 or air

Electrodes: Porous nickel electrodes

Electrolyte: Mixture of carbonate salts either lithium carbonate and potassium carbonate or lithium carbonate and sodium carbonate

Since it uses the carbonates of alkali metals as electrolyte in molten (liquid) phase, its operating temp must be in the range of (650°c – 700°).

The electrolytes are held in a sponge like ceramic matrix. When the mixture of carbonates salts are heated they become conductive to CO_3^{--} ions.

The carbonate ions so produced flow from cathode to anode where they combine with Hydrogen to produce CO_2. water (H_2O) and electrons and while combining with CO it produce CO_2 and electrons.

The electron flow from anode to cathode to generate electric power and heat

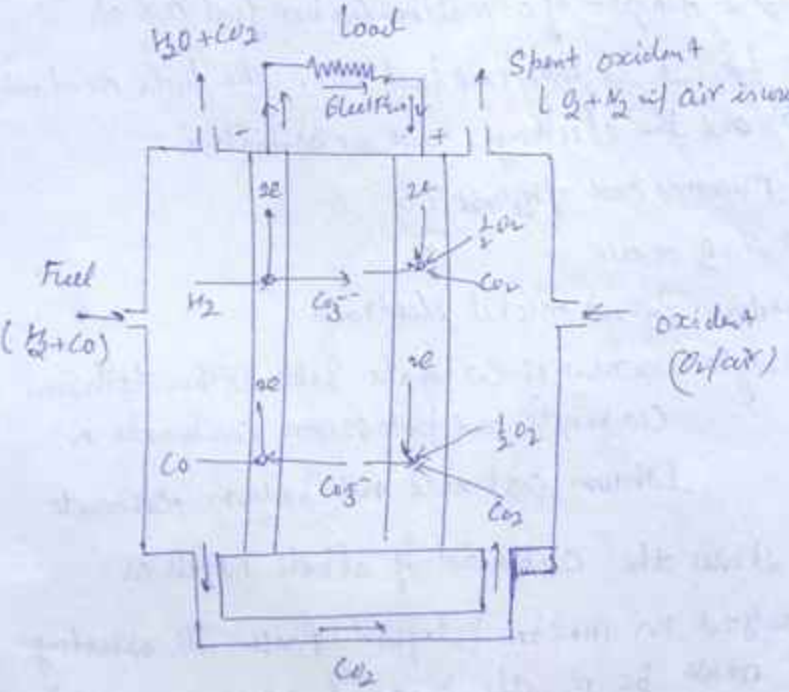
(when CO is heated it form CO_3^{--})

At anode $H_2 + CO_2^{--} = H_2O + CO_2 + 2e$

(when CO is heated then) $CO + CO_3^{--} = 2CO_2 + 2e$

At Cathode $O_2 + 2CO_2 + 4e = 2CO_3^{--}$

overall cell reaction $H_2 + CO + O_2 = H_2O + CO_2 + Heat$



Advantages of MCFC System:-

1. It uses Comparatively cheaper fuel like H_2 and CO.
2. It can utilize even fossil fuel like coal for producing the H_2 and CO by its gasification.
3. Discharge are mainly water vapour, CO_2 and N_2 (if air is used as oxidant) at a temp above 550°C. These hot gas can be used for generation of steam for power generation or as process heat for industries.
4. Efficiency of cell is high in the range of 60% with overall efficiency can be further increased by utilizing the heat of the products in Co-generation Plant.

Polymer Electrolyte Membrane Fuel Cell (PEMFC) or Solid Polymer Fuel Cell (SPFC):—

The Schematic diagram of a low temp. Polymer electrolyte membrane fuel cel is shown is fig

In this type of cell, the electrolyte is a solid polymer membranes of an organic material such as Polystrene sulphonic acid.

This Polymer is permeable to H^+ ions to pass through it when it is saturated with water but it does not conduct electrons other properties metals that this Polymer has high resistance to dehydration and oxidation coupled with high ionic Conductivity. The membrane is coated on with both sides with finely powdered Platinum which acts as Catalyst.

The fuel used is H_2 and oxidant as O_2. The electro-Chemical reaction are

At anode $H_2 = 2H^+ + 2e$

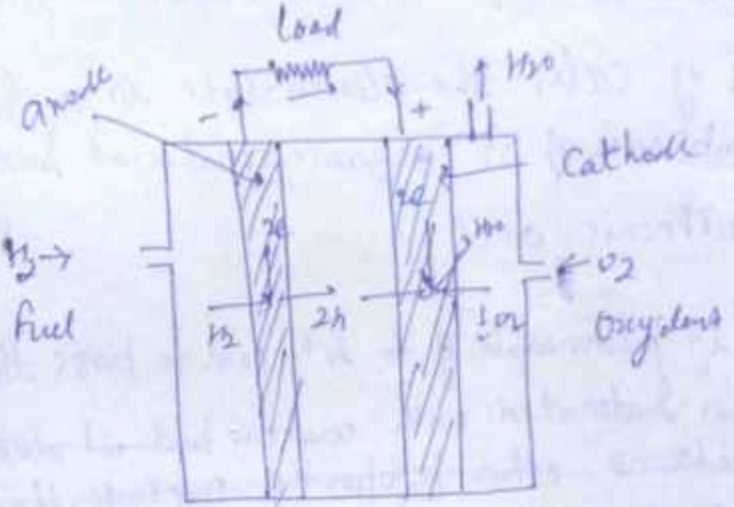
At Cathod $\frac{1}{2} O_2 + 2H^+ + 2e = H_2O$

Overall reaction $H_2 + \frac{1}{2} O_2 \rightarrow H_2O + Heat$

Advantages are of PEMFC are

1. It can be started quickly
2. Polymer membrane retains only limited quantity of water and rejects excess H_2O vapour produced in the cell.

3. It is comparatively cheap
4. It has no corrosion problem due to use of Platinum
5. It operates at low temp. of 90°C - 60°C



Solid oxide fuel cells (SOFC)

Certain solid ceramic oxides (eg. Zirconium dioxide) are able to conduct electricity at high Temp. therefore such ceramic oxides can be used as electrolytes in these fuel cells. The material is able to conduct O^{--} ions at high Temp. Therefore these cells operate at high Temp in the range of 650° to 1000°C. Due to high temp operation no catalyst is required.

The -ve electrode (anode) is made of porous nickel and the (cathode) with metal oxide

At the cathode the $\frac{1}{2}O_2$ molecules are split into oxygen oxygen ions with addition of two electrons. These O ions migrate to anode through electrolyte and combine with the hydrogen molecules with formation of H_2O and two electrons. Thus the chemical reactions are

at Anode $H_2 + O^{--} \rightarrow H_2O + 2e$

at Cathode $\frac{1}{2}O_2 + 2e \rightarrow O^{--}$

Overall rxn $H_2 + \frac{1}{2}O_2 \rightarrow H_2O + \text{heat}$