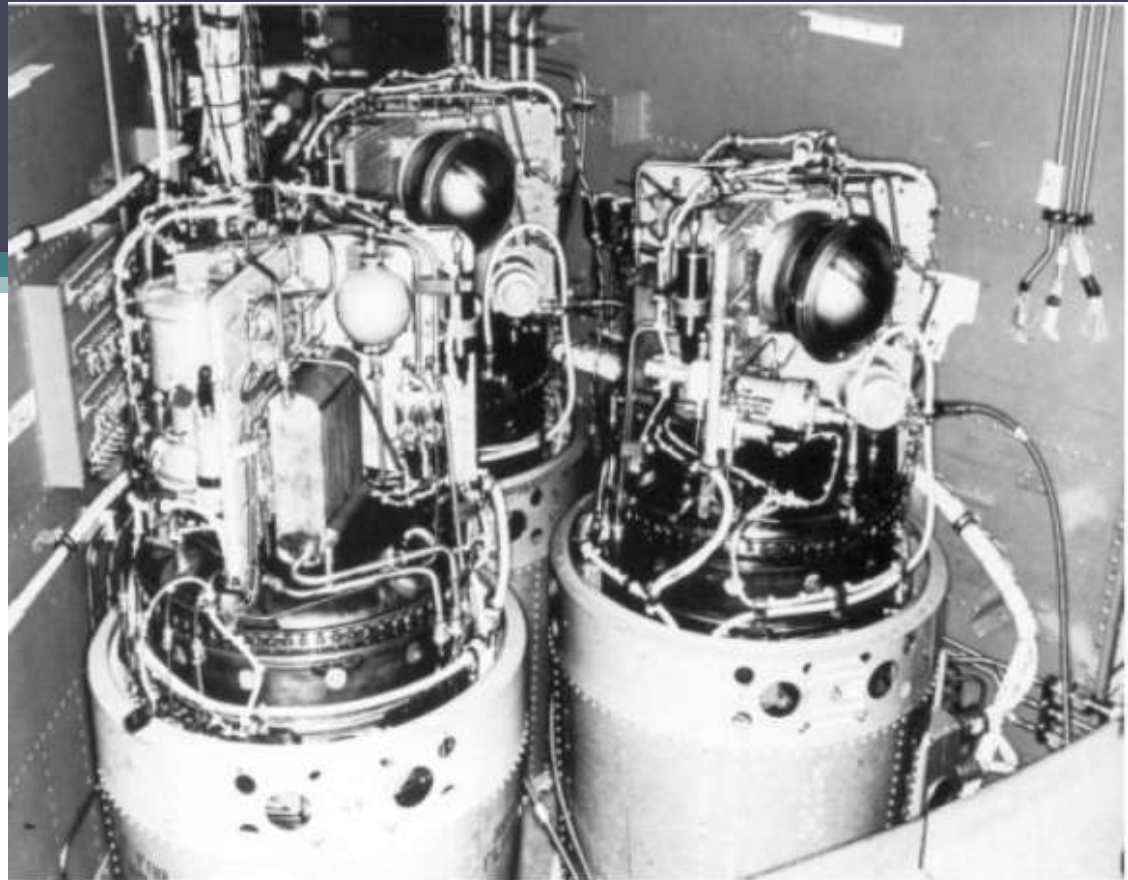


FUEL CELLS



FUEL CELLS

- A fuel cell is an electrochemical device that produces electricity without combustion by combining hydrogen and oxygen to produce heat and water

History of Fuel Cells

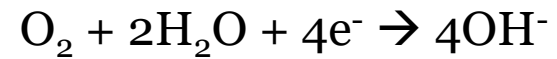
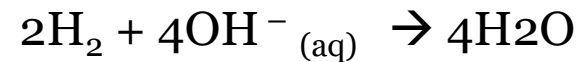
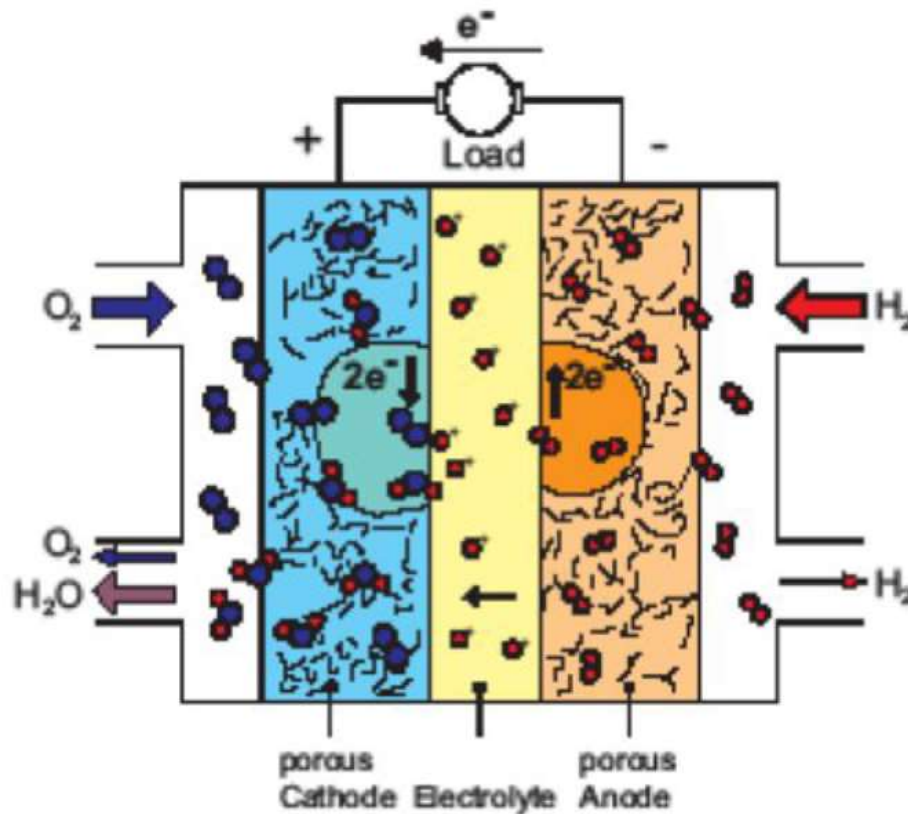
- Discovered by German scientist G.H. Shoenbein.
- First developed by William Grove.
- Developed by Grove while conducting research on electrolysis.
- Between 1930s to 1950s, British engineer Francis Thomas Bacon worked on developing alkaline fuel cells.
- He demonstrated a working stack in 1958
- The technology was licensed to Pratt and Whitney where it was utilized for Apollo spacecraft fuel cells

Advantages of Fuel Cells over conventional energy sources

- They produce zero or very low emissions, especially Green House Gases depending on the fuel used.
- Efficiency of fuel cells is more than efficiency of conventional heat engines.
- They have an excellent response time.
- They require minimal maintenance.
- No recharging is required.

Structure of Hydrogen fuel cell

Hydrogen Fuel Cell



Working Principle-

- A fuel cell is a device which uses Hydrogen (or a hydrogen rich fuel) and oxygen to create electricity by an electrochemical process.
- A single fuel cell consists of an electrolyte sandwiched between two electrodes (a porous anode and cathode.)
- 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, the oxygen combines with the electrons and, in some cases, with species like protons or water, resulting in water or hydroxide ions, respectively.

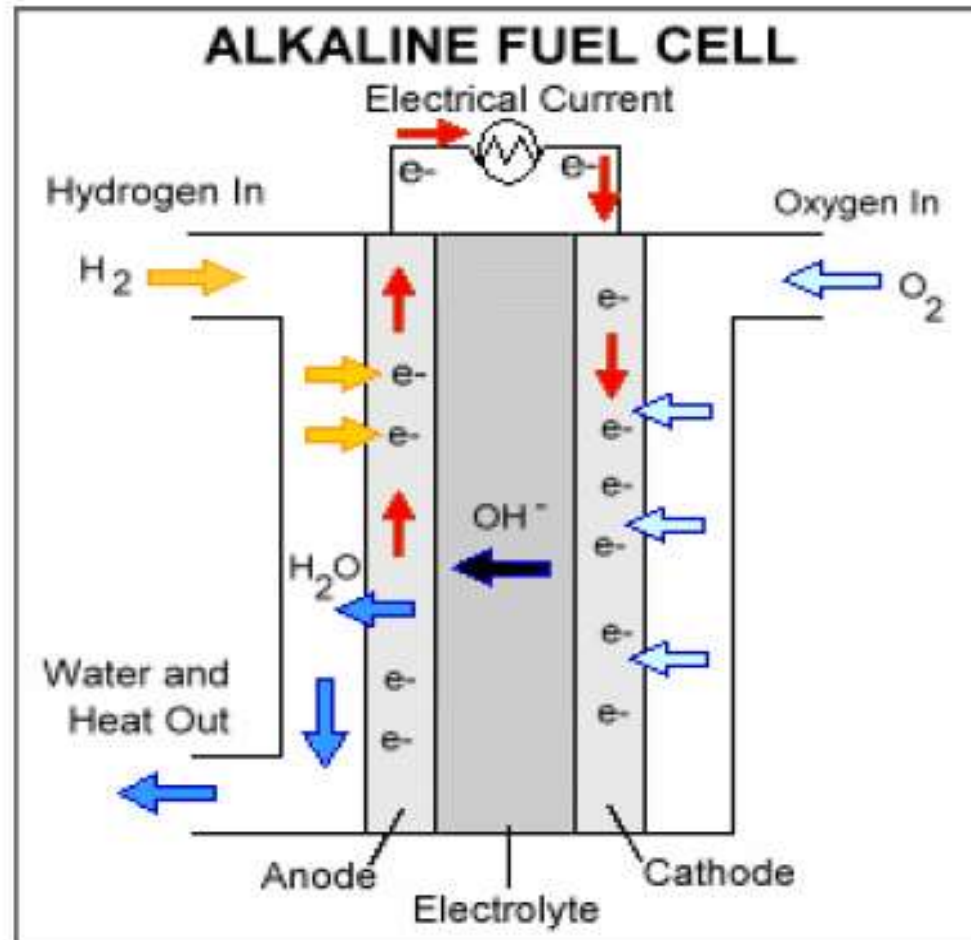
- The electrons from anode side of the cell cannot pass through the membrane to the positively charged cathode; they must travel around it via an electrical circuit to reach the other side of the cell. The movement of the electrons is an electrical current
- This is how generation of electric current takes place via a fuel cell

Factors on which Power generated depends

The power generated by fuel cell depends on factors such as:

- Fuel cell type.
- Cell size.
- Temperature at which it operates.
- Pressure at which the gases are supplies to the cell.

Diagram of an alkaline fuel cell



Anode Reaction: $2\text{H}_2 + 4\text{OH}^- \rightarrow 4\text{H}_2\text{O} + 4\text{e}^-$

Cathode Reaction: $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$

Alkaline fuel cells

- Alkaline fuel cells use an alkaline electrolyte such as 40% aqueous potassium hydroxide.
- In alkaline fuel cells travel through the electrolyte to the anode where they combine with the anode to form water and electrolyte
- These fuel cells use a solution of potassium hydroxide in water as the electrolyte and can use a variety of non precious metals as a catalyst at the anode and cathode.
- High temperature AFCs operate between 373K-523K.
- However more recent AFCs operate at lower temperatures between 296K-343K.

Advantages

- The efficiency is as high as 60%
- Cathode reaction is faster in an alkaline electrolyte; thus leading to high performance.

Disadvantages

- This cell is easily poisoned by CO₂.
- Even the smallest amount of CO₂ in air can affect the performance of the cell's operation, making it necessary to purify both the hydrogen and oxygen used in the cell.
- Susceptibility to poisoning reduces cell's lifetime.

Applications of fuel cells

- Fuel cells are very useful in remote locations, such as spacecraft, remote weather stations, rural locations including research stations, and in certain military applications.
- As of 2015, two fuel cell vehicles have been introduced in commercial market in limited quantities: the Toyota Mirai and the Hyundai ix35 FCEV. Additional demonstration models include the Honda FCX Clarity, and Mercedes-Benz F-Cell

- As of August 2011, there were a total of approximately 100 fuel cell buses deployed around the world.
- In 2013 there were over 4,000 fuel cell forklifts used in material handling in the US.
- In 2005 a British manufacturer of hydrogen-powered fuel cells, Intelligent energy, produced the first working hydrogen run motorcycle called the Emission Neutral Vehicle. The motorcycle holds enough fuel to run for four hours, and to travel 160 km (100 mi) in an urban area, at a top speed of 80 km/h (50 mph)



Toyota Mirai



Hyundai Nexo

Advantages of fuel cells

- Hydrogen being the most abundant element in the universe, makes hydrogen fuel cells more viable
- Hydrogen has the highest energy content.
- Hydrogen is non polluting
- Reduces dependency on fossil fuels

Disadvantages of fuel cells

- Hydrogen is very expensive, not because it is rare but because its difficult to generate, handle and store requiring bulky tanks like those for CNG.
- It can be stored at moderate temperatures and pressures in a tank containing a metal-hydride absorber or or carbon absorber, but both of these are very expensive.
- Fuel cells are often very bulky and can not be used everywhere.
- The actual cells in which power generated is stored can store only a small amount of power. This reduces the reliability of the entire process