



# **SNS COLLEGE OF TECHNOLOGY**

**Coimbatore-35**  
**An Autonomous Institution**

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## **DEPARTMENT OF MECHANICAL ENGINEERING**

**19MEE402– FUEL CELL TECHNOLOGY**  
IVYEAR & V IISEM

**UNIT 5 – FUELS CELLS FOR ELECTRIC VEHICLES**

**FUELS CELL TYPES & TECHNOLOGIES**

# CONTENT

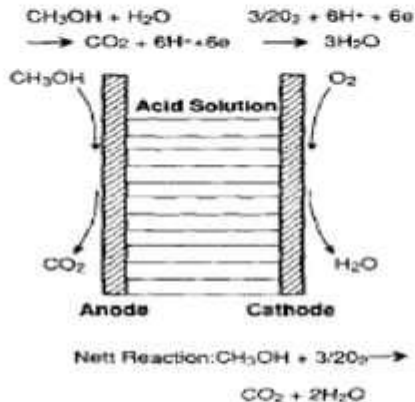
- Introduction.
- Construction of Fuel Cell.
- Working of Fuel Cell.
- Types of Fuel Cell.
- Advantages of Fuel Cell.
- Disadvantages of Fuel Cell.
- Application of Fuel Cell.

# INTRODUCTION

What is Fuel cell?

- A fuel cell is an electrochemical device that converts energy produced from a chemical reaction into electrical energy.
- More specifically it is an electrochemical device that combines hydrogen and oxygen to produce electricity, with water and heat as its by-product.
- Chemical Energy → Electrical Energy.

# CONSTRUCTION



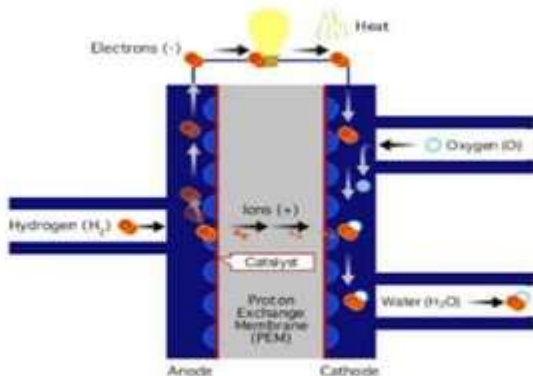
- **Anode**- Negative post of the fuel cell. Conducts the electrons that are freed from the hydrogen molecules so that they can be used in an external circuit. Etched channels disperse hydrogen gas over the surface of catalyst.

- **Cathode**- Positive post of the fuel cell. Etched channels distribute oxygen to the surface of the catalyst. Conducts electrons back from the external circuit to the catalyst. Recombine with the hydrogen ions and oxygen to form water.
- **Electrolyte**- Proton exchange membrane. Specially treated material, only conducts positively charged ions. Membrane blocks electrons.
- **Catalyst**- Special material that facilitates reaction of oxygen and hydrogen. Usually platinum powder very thinly coated onto carbon paper or cloth. Rough & porous maximizes surface area exposed to hydrogen or oxygen. The platinum-coated side of the catalyst faces the PEM.

## WORKING

- A fuel cell generates electrical power by continuously converting the chemical energy of a fuel into electrical energy by way of an electrochemical reaction. The fuel cell itself has no moving parts, making it a quiet and reliable source of power. Fuel cells typically utilize hydrogen as the fuel, and oxygen (usually from air) as the oxidant in the electrochemical reaction. The reaction results in electricity, by-product water, and by-product heat.

- When hydrogen gas is introduced into the system, the catalyst surface of the membrane splits hydrogen gas molecules into protons and electrons. The protons pass through the membrane to react with oxygen in the air (forming water). The electrons, which cannot pass through the membrane, must travel around it, thus creating the source of DC electricity.

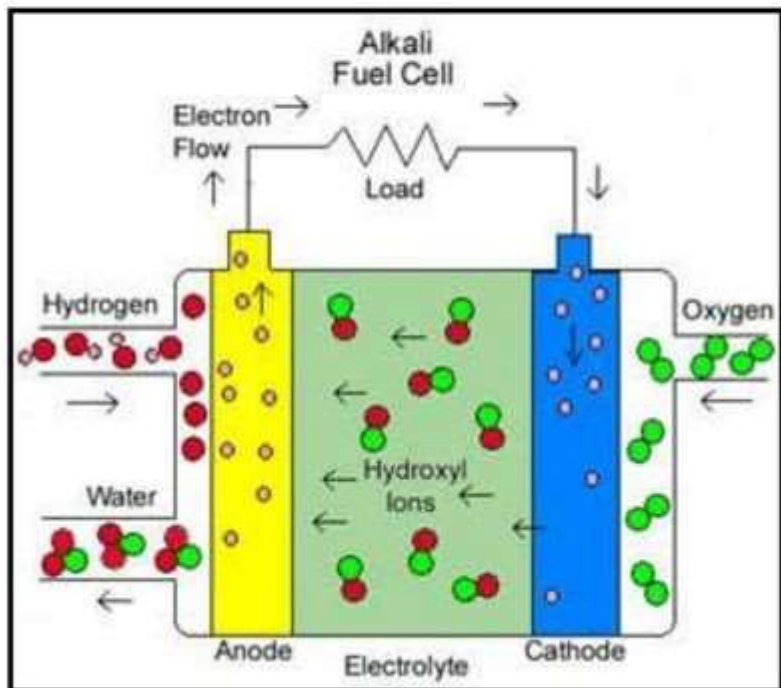


# TYPES OF FUEL CELL

1	Alkaline FC (AFC)
2	Phosphoric Acid FC (PAFC)
3	Molten Carbonate FC (MCFC)
4	Solid Oxide FC (SOFC)



# ALKALINE FUEL CELL

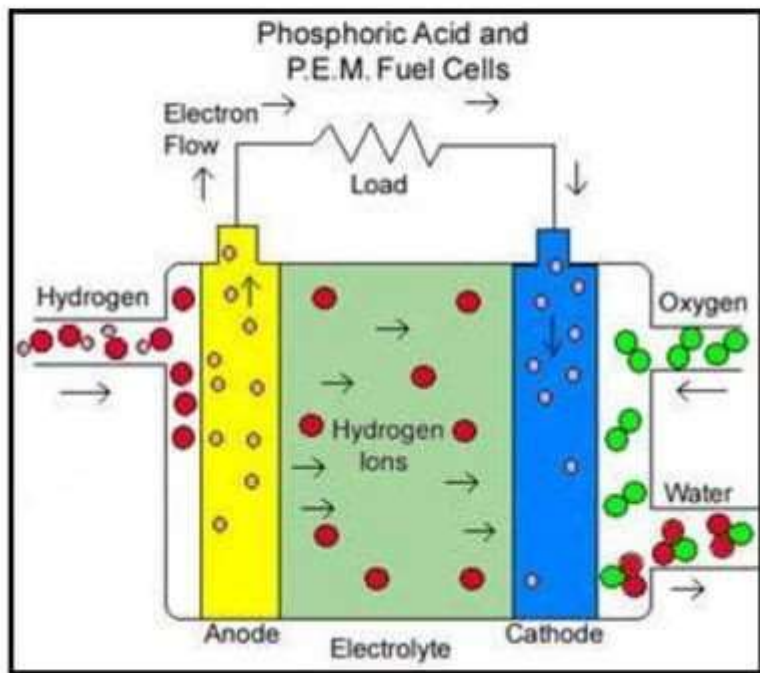


- This type of fuel cell was been introduced in the early 1960's. As the electrolyte used for this device is aqueous alkaline solution like potassium hydroxide, the procedure for electricity consumption is rather expensive.

**It has;**

- compressed hydrogen and oxygen fuel.
- potassium hydroxide (KOH) electrolyte.
- ~70% efficiency.
- 150 °C - 200 °C operating temp.
- 300W to 5kW output requires pure hydrogen fuel and platinum catalyst.

# PHOSPHORIC ACID FUEL CELL

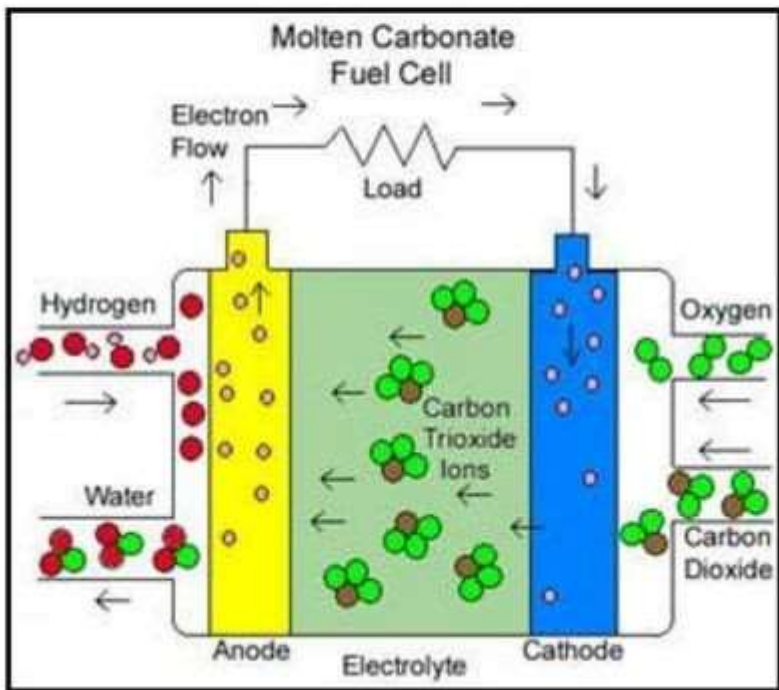


- Molten phosphoric acid is the electrolyte used in this type of fuel cell. It operates at high temperature up to 200 degree Celsius. It has an efficiency of up to 55%. This type of fuel cell is most commonly used in commercial cars.

**It has;**

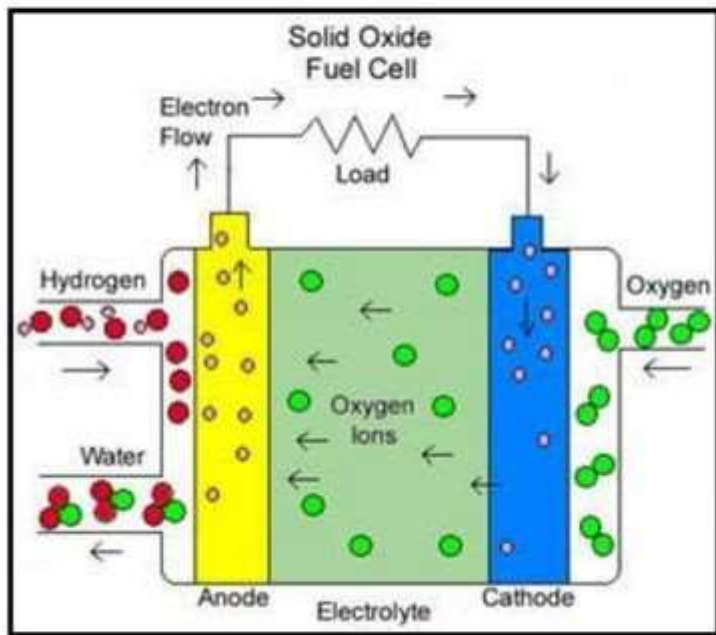
- phosphoric acid electrolyte.
- 40 - 80% efficiency.
- 150° C - 200° C operating temp.
- 11 MW units have been tested.
- sulphur free gasoline can be used as a fuel.
- The electrolyte is very corrosive.
- Platinum catalyst is very expensive.

# MOLTEN CARBONATE FUEL CELL



- Molten alkaline carbonate like sodium bicarbonate is used as the electrolyte. They can produce high powers up to 100 Mega Watts. Thus they can be used as high power generators. They can also be operated at high temperatures up to 650 degree Celsius. They are not so expensive in production and hence can be used for commercial uses. It has an efficiency of almost 55%.

# SOLID OXIDE FUEL CELL





- This is one of the most commercially used fuel cell as they have the highest operating life. It has a very high operating temperature of 1,000 degrees Celsius. But other parts of the fuel cell may not be able to withstand at this temperature making it highly unstable. But, when used in a continuous state they can be highly reliable. At high temperatures the device can produce water in the form of steam which can be easily transported through steam turbines to produce more electricity, thus increasing the efficiency of the system. This device is also special in the case where a wide variety of fuels can be used. Most of the petroleum products can be used as the fuel. The electrolyte used in the cell is called yttria stabilized zirconia (YSZ). This electrolyte is good for large scale power generation and has the same characteristics as all the other electrolytes.
- As the device has a very high operating temperature, there are some disadvantages as well. There may be unwanted number of reactions taking place inside the cell due to the high temperature. As a result of these reactions carbon dust and also graphite may be built up on the anode making it insufficient from reacting with the catalyst.



## Comparison of Fuel Cell Technologies

Fuel Cell Type	Common Electrolyte	Operating Temperature	Typical Stack Size	Efficiency	Applications	Advantages	Disadvantages
<b>Polymer Electrolyte Membrane (PEM)</b>	Perfluoro sulfonic acid	50-100°C 122-212° typically 80°C	< 1kW-100kW	60% transportation 35% stationary	<ul style="list-style-type: none"> <li>• Backup power</li> <li>• Portable power</li> <li>• Distributed generation</li> <li>• Transportation</li> <li>• Specialty vehicles</li> </ul>	<ul style="list-style-type: none"> <li>• Solid electrolyte reduces corrosion &amp; electrolyte management problems</li> <li>• Low temperature</li> <li>• Quick start-up</li> </ul>	<ul style="list-style-type: none"> <li>• Expensive catalysts</li> <li>• Sensitive to fuel impurities</li> <li>• Low temperature waste heat</li> </ul>
<b>Alkaline (AFC)</b>	Aqueous solution of potassium hydroxide soaked in a matrix	90-100°C 194-212°F	10-100 kW	60%	<ul style="list-style-type: none"> <li>• Military</li> <li>• Space</li> </ul>	<ul style="list-style-type: none"> <li>• Cathode reaction faster in alkaline electrolyte, leads to high performance</li> <li>• Low cost components</li> </ul>	<ul style="list-style-type: none"> <li>• Sensitive to CO<sub>2</sub> in fuel and air</li> <li>• Electrolyte management</li> </ul>
<b>Phosphoric Acid (PAFC)</b>	Phosphoric acid soaked in a matrix	150-200°C 302-392°F	400 kW 100 kW module	40%	<ul style="list-style-type: none"> <li>• Distributed generation</li> </ul>	<ul style="list-style-type: none"> <li>• Higher temperature enables CHP</li> <li>• Increased tolerance to fuel impurities</li> </ul>	<ul style="list-style-type: none"> <li>• Pt catalyst</li> <li>• Long start up time</li> <li>• Low current and power</li> </ul>
<b>Molten Carbonate (MCFC)</b>	Solution of lithium, sodium, and/or potassium carbonates, soaked in a matrix	600-700°C 1112-1292°F	300 kW-3 MW 300 kW module	45-50%	<ul style="list-style-type: none"> <li>• Electric utility</li> <li>• Distributed generation</li> </ul>	<ul style="list-style-type: none"> <li>• High efficiency</li> <li>• Fuel flexibility</li> <li>• Can use a variety of catalysts</li> <li>• Suitable for CHP</li> </ul>	<ul style="list-style-type: none"> <li>• High temperature corrosion and breakdown of cell components</li> <li>• Long start up time</li> <li>• Low power density</li> </ul>
<b>Solid Oxide (SOFC)</b>	Yttria stabilized zirconia	700-1000°C 1202-1832°F	1 kW-2 MW	60%	<ul style="list-style-type: none"> <li>• Auxiliary power</li> <li>• Electric utility</li> <li>• Distributed generation</li> </ul>	<ul style="list-style-type: none"> <li>• High efficiency</li> <li>• Fuel flexibility</li> <li>• Can use a variety of catalysts</li> <li>• Solid electrolyte</li> <li>• Suitable for CHP &amp; CHHP</li> <li>• Hybrid/GT cycle</li> </ul>	<ul style="list-style-type: none"> <li>• High temperature corrosion and breakdown of cell components</li> <li>• High temperature operation requires long start up time and limits</li> </ul>

# ADVANTAGES

- Water is the only discharge (pure H<sub>2</sub>)
- Higher efficiency than conventional engines.
- Excellent part load characteristics.
- Zero emission.
- Long operating period between failures.
- No rotating parts in the main hard ware components.
- Negligible noise pollution.

# DISADVANTAGES

- CO<sub>2</sub> discharged with methanol reform.
- Little more efficient than alternatives.
- Technology currently expensive.
  - Many design issues still in progress.
- Hydrogen often created using “dirty” energy (e.g., coal).
- Pure hydrogen is difficult to handle.

# APPLICATIONS

- Can be used as power sources in remote areas.
- Can be used to provide off-grid power supplies.
- Can be applicable in both hybrid and electric vehicles.
- Waste water treatment plant and landfill.
- Cellular phone, laptop and computers.
- Hospitals, credit card centres and police stations.
- Buses, Car, Planes, Boats, Fork lift, Trains
- Vacuum cleaner.
- Telecommunication, MP3 players, etc.

# **REFERENCES**

**Fuel Cells: Principles, Design, and Analysis**

Shripad T. Revankar, Pradip Majumdar

**Fuel Cell Handbook (Seventh Edition)**

By EG&G Technical Services, Inc.

**-THANK YOU**