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Technical Aspect of Fuel Cell

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Abstract: **This paper introduces a great deal of research in the field of fuel cells, which uses oxygen and hydrogen as a fuel. Fuel cells offers the best standard for meeting the requirements of zero emission vehicles, and thus expected to be the prime user of hydrogen in the near future. Fuel cells overcome the problem of geographical limitations that occur in other form of renewable energy sources (i.e wind, solar,p.v cell etc.).This paper looks at all type of fuel cells and give a brief overview of the technologies used in these fuel cells and their present status of development.**

Keywords: **Fuel cells, Renewable energy.**

1. INTRODUCTION

The ever increasing demand for electrical energy and to overcome the problem of geographical limitations that found in the renewable energy sources,we must look at the technical viability of fuel cells.The fuel cells has,a renewable energy sorce is considered one of the most desirable source of electrical power.Fuel cells have high efficiency, low environmental impact and high reliability.The fuel cells in its elemental form consumes Nitrogen as a fuel and produces

Fuel cells is a device which converts chemical energy of gases (such as Hydrogen,Oxygen) into electrical energy through a chemical. With respect to the electrolyte classification, the fuel cells system are of six types:

1. Solid oxide fuel cell (SOFC)
2. Phosphoric acid fuel cell (PAFC)
3. Molten carbonate fuel cell (MCFC)
4. Proton exchange membrane fuel cell (PEMFC)
5. Alkaline oxide fuel cell (AOFC)
6. Direct Methanol fuel cell (DMFC)

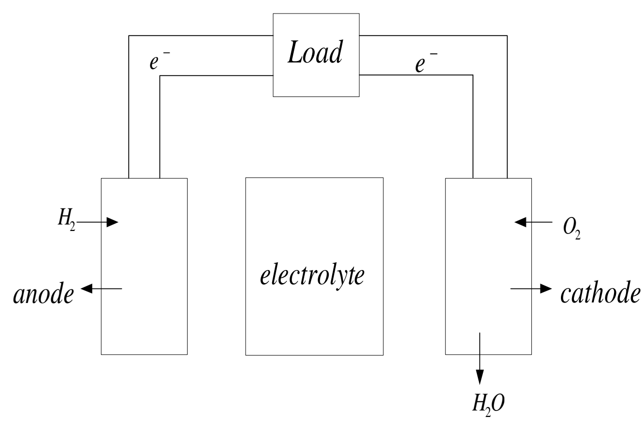
2. SOLID OXIDE FUEL CELL

Solid Oxide fuel Cell consists of two electrodes known as anode and cathode which are separated by electrolytes (made up of ceramic). Hydrogen is passed over the anode and oxygen is passed over the cathode. Hydrogen ions are formed together with electrons at the cathode. Hydrogen ions moves to the cathode through the electrolytes and electrons produced at the anode flow through an external circuit to the cathode. At the cathode, hydrogen ions and electrons combine with oxygen to form water. The flow of electrons through the external circuit provides the cell current. The overall reaction gives water as its by-product, so fuel cells are environmental friendly [4], [5], [6]. The chemical reaction equation of anode and cathode is given as [5]-[6]:

At anode;
$$2H_2 + 2O^{2-} \rightarrow 2H_2O + 4e^-$$

At cathode;
$$O_2 + 4e^- \rightarrow 2O^{2-}$$

Overall reaction;
$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \qquad (3)$$



The anode is typically porous nickel-zirconium cermets that serve as the electro catalyst, which can be electronically conductive. It allows fuel gas to reach the electrolyte interface, and catalyzes the fuel oxidation reaction [8], [7].

The Fuel Cell Development Program in India:

1. Technology Development and Demonstration for 5 kW tubular SOFC and 1 kW Planar Multi-cell PEMFC systems complete with fuel generator and power conditioner.

2. Setting up of facilities and infrastructure for fabrication/ integration of fuel cell components and other subsystems, especially thin ceramic films for SOFC and Membranes and MEA (Membrane Electrode Assembly) for PEMFC.

3. Modular Cell design for standardization and Scale up.

4. In India Fuel Cell Program is largely supported by Government. The major organization working in the field include:

   a. BHEL (Hyderabad) is working on developing PAFC and MCFC for distributed power generation and also focuses on preparing catalyst and fuel reformer to be used in fuel cell power plants. They have demonstrated some distributed power systems.

   b. TERI is working on MCFC stack development for power generation and procedure for making electrodes, electrolyte tapes and electrolyte carriers.

   c. SPIC Science Foundation (Chennai) is engaged in PEMFC technology for applications such as stationary, portable and transportation purposes. It is also involved in designing PEM electrolyser and hydrogen sensors.

   d. GAIL is actively involved in establishing fuel infrastructure for fuel cell vehicles in India.

   e. Basic research on anode, cathode, electrolyte and interconnect materials for SOFC technology is carried out by BARC (Mumbai) and MIT (Chennai).

   f. IISc (Bangalore) and CGCRI (Kolkata) are involved in developing SOFC systems. A methanol reformer was developed and integrated with a fuel cell system by IISc, Bangalore.

   g. CECRI (Karaikudi) has developed and tested MCFC stack.

3. PHOSPHORIC ACID FUEL CELLS

PAFC are a type of fuel cells that cites liquid phosphoric acid as an electrolyte. Developed in the Mid 1960s and field tested since 1970s,they have improved significantly in stability performance and cost .fuel cells, which use phosphoric acid solution as the electrolyte, are called phosphoric acid fuel cells. First of all, the phosphoric acid in aqueous solution dissociates into phosphate ions and hydrogen ions; the hydrogen ions (H^{+}) act as the charge carrier. Phosphoric acid is chemically stable and is easy to handle. It also has an extremely low vapour pressure even at an operating temperature of 200°C.This implies that phosphoric acid in the electrolyte layer cannot be easily discharged from the fuel cells together with the cell exhaust gas, although even such minute discharge, result in the degradation of cell performance in the long term.

Chemical Reaction
Anode reaction: $2H_2 \rightarrow 4H^{+}+e^{-}$
Cathode Reaction: $O_2+4H^{+}+4e^{-} \rightarrow 2H_2O$
Overall all reaction: $2H_2+O_2 \rightarrow 2H_2O$
Electrical efficiency of System: 40%-42%

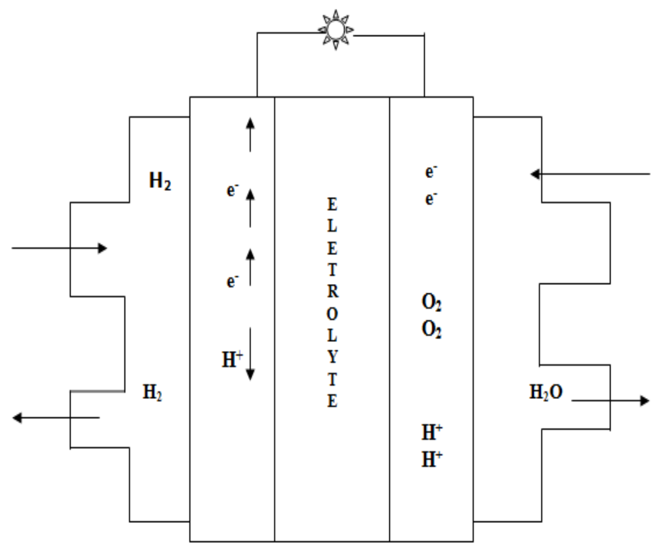


Fig 2 Phosphoric Acid Fuel Cell.

4. PROTON EXCHANGE FUEL CELL

One main candidate for clean high efficiency power production in future cars is the proton exchange membrane fuel cells. In a fuel cell powered engine, the fuel is converted to electrical energy through electrochemical reaction instead of combustion .An electric motor,which generally operates at a very high efficiency, powers the vehicle. Thus a fuel cell powered car can run for long distance with the same amount of fuel compared to a conventional car. Carbon-Dioxide emissions are consequently lowered, because smaller amounts of fuel are consumed for the same distance travelled.In addition the low temperature in the process practically eliminate the production of no_x and so_x.[3]

The PEM allows only the positively charged ions to pass through it to the cathode.The negatively charged electrons must travel along an external circuit to the cathode creating an electric current. The commonly available fuel cells can be classified according to temperature, medium temperature and high temperature fuel cells [4].Proton exchange membrane are a major determinant of fuel cell life time. For automotive applications, standards call for high level of operation stability, reportedly 5500 hours for cars and 20000 hours for buses.

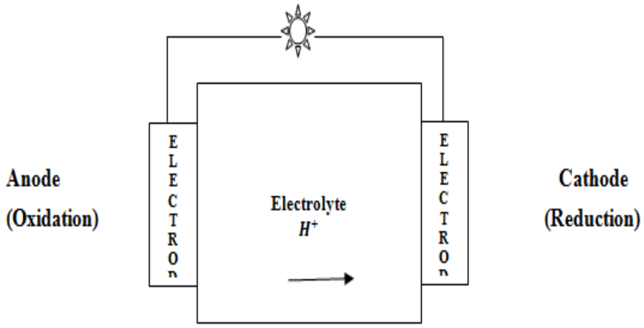


Fig. 3 Proton Exchange Membrane Fuel Cell.

At the cathode, the electrons and positively charged hydrogen ions combine with oxygen, which flows out of the cell.

Chemical reaction;
At the anode: $H_2 \rightarrow 2H^+ + 2e^-$
At the cathode: $\frac{1}{2}\ O_2 + 2H^+ + 2e^- \rightarrow H_2O$
Overall Reaction: $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$

5. MOLTEN CARBONATE FUEL CELL

MCFC are currently being demonstrated in several sites around the world,MCFC are high temperature fuel cells that operates at temperature of 600°C and above.MCFC use carbonate salts of alkaline metals as their electrolyte.In general fuel cells are not too different from traditional batteries.there is an anode,cathode and electrolyte.In a molten carbonate fuel cell,carbonate salts are the electrolyte,heated to 650°C,The salts melt into a molten state that can conduct ions(CO_3^-),Between cathode and anode. At the anode,hydrogen reacts with the ions to produce water, carbon dioxide and electrons.At the cathode, oxygen from air and carbon dioxide recycled from the anode react wid the electron to form co_3 ions that replenish the electrolyte and transfer current through the fuel cell.[1]

Advantages of MCFC:

One of the major advantages of fuel cells in general is the absence of polluting emissions. Like many others telecom operators, deutsche telekom faces environmental restrictions when employing traditional back up generators, especially in offices located in densely populated areas .other major advantage of the MCFC are linked to the absence of an external reformer.

Disadvantages of MCFC:

Two major difficulties with molten carbonate technology pets it at a disadvantages compared to solid oxide cells. One is the complexity of working with a liquid electrolyte rather than a solid.The other derives from the chemical reaction inside a molten carbonate cell.Also the nickel electrode operates in a very hot and corrosive environment, thus life is limited.

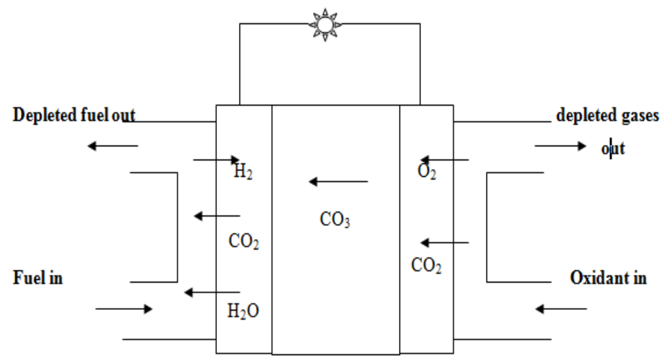


Fig. 4 Molten Carbonate Fuel Cell.

Chemical reactions:
At Cathode: $2CO_2 + O_2 + 4e^- \rightarrow 2CO_3 2^-$
At Athode: $2H_2 + 2CO_3 2^- \rightarrow 2H_2O + 2CO_2 + 4e^-$
Overall Reaction: $2H_2 + O_2 \rightarrow 2H_2O$

6. CONCLUSION

This paper deals with the comparative study of different types of fuel cells.
Table 1 shows comparison between different Fuel Cells.

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Table 1: Shows comparison between different Fuel Cells.

Technology	**Carbonate(MCFC)**	**Phosphoric acid**	**SOFC**	**PEM/ SOFC**	**PEM**
System Size range	300kW-2.8MW	400kW	up to 200kW	<10kW	up to 100kW
Typical Application	Utilities, large universities, industrial base- load	Commercial buildings - Base load	Commercial buildings - Base load	Residential and small commercial	Transportation
Fuel	Natural gas, Bio gas, others	Natural Gas	Natural Gas	Natural Gas	Hydrogen
Advantages	High Efficiency, scalable, fuel flexible & CHP	CHP	High efficiency	Load following & CHP	Load following & low temperature
Electrical Efficiency	43%-47%(higher turbine or organic rankine cycle)	40%-42%	50%-60%	25%-35%	25%-35%
Combined Heat &Power(CHP)	Steam, hot water, chilling & boffoming cycles	Hot water chilling	Depends on technology used	suitable for facility heating	No, which is an advantage for transportation