A COMPARITIVE STUDY OF DIFFERENT FUEL CELLS

[1]Dr.U.M.Netravati, [2]Dr. Veeragangadhar swamy.T.M, [3]Diwakar.B, [4]Girish.K.M
[1,2] Professor, [3,4] Asst.Professor
[1,3,4]Department of EEE, [2]Department of CSE DEPT
RYMEC, Ballari, Karnataka

Abstract : Modern life is unimaginable without energy and also transportation. Most of the energy is generated by fossil fuels and burning these fuels worsening the environmental conditions and leading towards global warming. Nevertheless, nation has a great distance to travel to achieve environmental superiority alike to those appreciated in developed providence. Pollution control is the ultimate challenge for the nation. Environmental problems are the crucial courses of disease, healthiness problems and future resource footprint for India. Therefore there is a necessary to search out a new renewable energy sources like fuel cells and study about type of fuel cell suitable for particular application.

IndexTerms **- Renewable energy source, Fuel cell (FC), Alkaline, Phosphoric-acid, Molten-Carbonate, Direct-methanol, Solid-oxide. Polymer or proton exchange membrane.**

I. INTRODUCTION

Chemical energy is changed into electrical power by a chemical reaction from a device called fuel cell. It is similar to a battery. Both obtain electrical energy from chemical energy. Battery has storage of energy in it and once it is finished the battery is not useful or it has to be recharged by the external electrical supply. But H2 is the fundamental fuel in the fuel cell. It furthermore needs oxygen unlike a battery a fuel cell, employs an external supply of chemical energy will run indefinitely, as long as it is supplied with sources of H2 and O2. In a very efficient way the oxidation of hydrogen takes place electrochemically and there is no any combustion exists. In the oxidation process, atoms of H2 react with atoms of O2 to create H2O. In this course electrons are let free, flood in an outside circuit as an electric current.

FC has two electrodes i.e. Anode and Cathode. Anode is positive electrode. Cathode is negative electrode. At these electrodes the reactions that produce electricity will take place. A FC accommodates electrolyte. This electrolyte carries from one electrode to the other, electrically charged particles. Catalyst is used always to speeds up the reactions at the electrodes. The electrolyte takes an important part. It allows only the suitable ions to be passed in between the anode and cathode. The electrolyte prevents the chemical reactions if any substances or electrons could move through the electrolyte. The electrolyte may be a solid or liquid electrolyte. The fuel cell is classified depending on the sort of a definite fuel, material and is suitable for different applications. The FC is used to supply a motor and enlightening a bulb in a city. Fuel cells vary from producing a few watts to several mega watts of electricity in bulky energy plants.

II. FUEL CELL TYPES AND COMPARISON

FC uses hydrogen from a number of hydrocarbon fuels for example propane, gasoline, natural gas, methanol and biomass. Hydrogen is obtained by separating water molecule into hydrogen and oxygen in an electrolyser. It is also extracted from an air.
The important features of fuel cell are:

1) Electrolyte in the cell determines the type of fuel cell.
2) Fuel (hydrogen)
3) The anode catalyst made up of very fine platinum powder. This anode catalyst breaks the fuel into ions and electrons
4) The cathode catalyst made up of nickel.

The classification of fuel cells is mainly depending on the sort of electrolyte used in it. Classification also gives type of catalyst used; the manner of chemical reactions happens in a cell, the temperature range and other factors.
The different types of fuel cells are:

1) Alkaline.
2) Phosphoric-acid.
3) Molten-Carbonate.
4) Direct-methanol.
5) Solid-oxide.
6) Polymer or proton exchange membrane.

1) Alkaline FC:

Among the FCs the first developed FC was the alkaline. The electrolyte employed in this FC is KOH (potassium hydroxide) in water. It uses Catalyst as different metals at cathode and anode. The operating temperature is 1000 C to 2500 C. The main drawback of alkaline fuel cell is that is poisoned easily by small amounts of CO2. Even a small quantity of CO2 in the air affects the operation of cell. Therefore it is required to filter and clean both the O2 and H2 utilized in the alkaline cell that makes it very costly. The cell lifetime will also be reduced. Fig. 1 shows the schematic diagram of alkaline fuel cell.

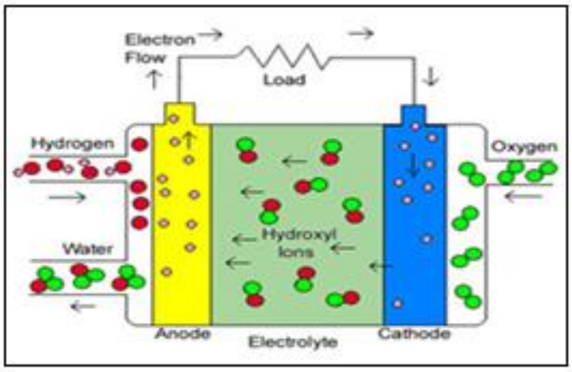

Fig.1 Diagram of alkaline fuel cell

2) Phosphoric-acid FC:

The catalyst used in this is phosphoric acid. Platinum is utilized as a catalyst to enhance the hydrogen ion release speed on the anode. The operating temperature is 1600C to 2200C. This temperature is high as it will result in power and heat loss if the hotness is not taken out or properly handled. The phosphoric acid fuel cell is less powerful compared with others for the identical weight and capacity. This fuel cell is quite large and heavy. The foremost shortcoming of this cell is the making apply of an acidic electrolyte that raises the oxidation and decomposition of components exposed to it. Fig. 2 shows the schematic diagram of Phosphoric-acid fuel cell.

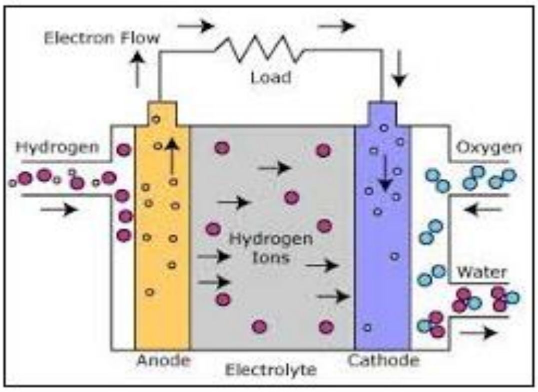

Fig.2 Diagram of Phosphoric-acid fuel cell

3) Molten-Carbonate FC:

Catalyst used in this FC is lithium potassium carbonate salt. This lithium potassium carbonate salt is liquefied at high temperature. The temperature of operation of this fuel cell is 6500C. Their catalyst and nickel electrode are low-priced as referenced to the platinum in other type of fuel cells. Because of the more temperature of operation the hydrocarbon fuels are rehabilitated to hydrogen inside the fuel cell. This conversion is called as internal reforming. This fuel cell is not prone to carbon dioxide and carbon monoxide poisoning. The fuels rich in carbons be fond of gases prepared from coal are well-matched to the arrangement. The main drawback of molten carbonate fuel cell is the sluggish start up period because of their high temperature of operation. The more temperature at which this cell operates and corrosive electrolyte used accelerate component breakdown. Corrosion decreases the lifespan of the cell. This fuel cell requires strong thermal shielding and it is difficult to develop durable material for the high temperature operating environment. Fig.3 shows the schematic diagram of Molten-Carbonate fuel cell.

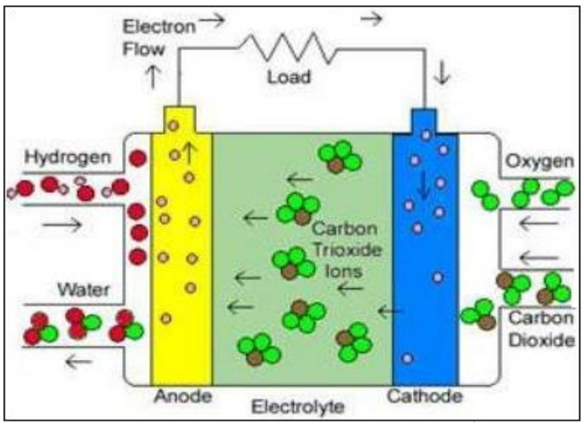

Fig.3 Diagram of Molten-Carbonate fuel cell

4) Direct-methanol FC:

This cell uses polymer film as the electrolyte. These cells do not necessitate a fuel reformist, as the catalyst at the anode itself pull the hydrogen from fluid methanol. The operating temperature of direct-methanol FC is 5000C -12000C. This fuel cell is new one powered by pure hydrogen. Fig.4 shows the schematic diagram of Direct-methanol fuel cell.

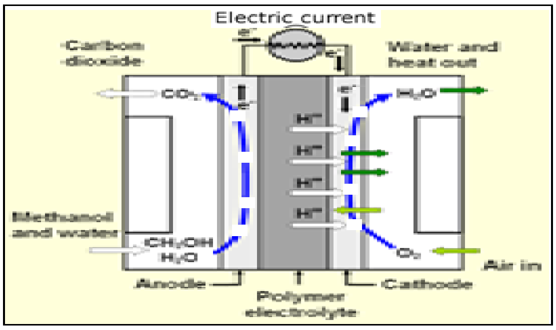

Fig.4 Diagram of Direct-methanol fuel cell

5) Solid-Oxide FC:

The catalyst used in the FC is a solid material i.e. material of ceramic called Yttric-Stabilized-Zirconium (YSZ). The configuration of solid-oxide FC is not like other FCs because it is made entirely of solid material. Its configuration is not a flat plane but designed as rolled tubes. The operating temperature of SOFC is 8000 C to 10000 C. This fuel cell is also exclusive as rather of positively charged ions of hydrogen travel from the anode to cathode while in the case of all other fuel cells, here -vely charged ions of oxygen pass through from the cathode to the anode. SOFC is proficient of internal reforming of hydrocarbons such as propane, butane and methane. The main drawback of this fuel cell is high temperature of operation and slow commence up time. It requires thermal protecting to keep hold of heat and guard personnel that are not suitable for transportation and small materials is also a big problem. Fig.5 shows the schematic diagram of Solid-Oxide fuel cell.

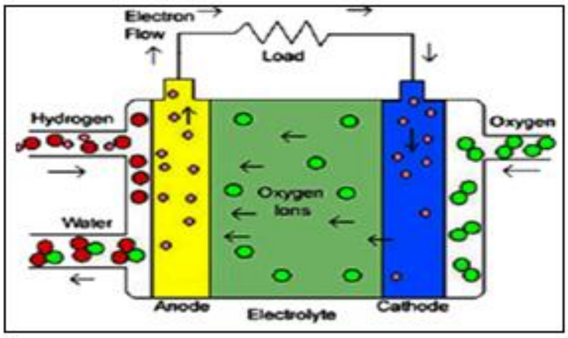

Fig.5 Diagram of Solid-Oxide fuel cell

6) Proton exchange membrane FC(PEMFC):

It is as well named as polymer electrolyte fuel cell. The electrolyte is hard polymer that looks just like a kitchen plastic wrap. PEM fuel cell uses platinum (Pt) catalyst with porous carbon electrodes. The operating temperature is about 800C. The electrolyte layer allows only either positive or negative ions to travel across as a one way. It does not allow electrons to pass through. The advantages of PEMFC are low volume and weight with better power to weight ratio, quick start, less thermal wear to components because of low operating temperature in comparison with other fuel cells. PEMFC are best suited for quick start up requirements such as in vehicles, backup power and electronic devices. In vehicles like car, scooter, auto rickshaw, motor cycle and buses PEMFC is being used instead of petrol and diesel. The main plus points of this fuel cell is it needs only H2 and O2 form the H2O and air to activate and does not necessitate fluids that lead to corrosion similar to other fuel cells. Fig.6 shows the schematic diagram of Proton exchange membrane fuel cell.

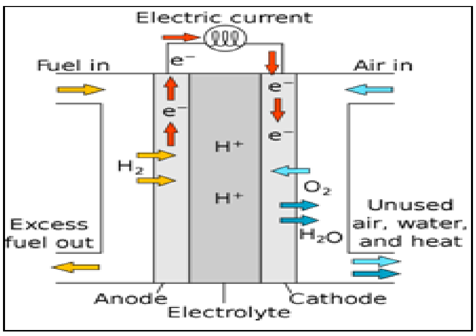

Fig.6 Diagram of PEMFC

Table: 1 Comparison of different types of FCs

FC	Operating Temp.	%η	Output Power	Applications
AFC	100^0- 250^0C	70%	300W- 5KW	Aerospace, underwater environments
PAFC	160^0- 220^0C	80%	200KW -11MW	High energy demands such as hospitals, schools, offices, stores.
MCFC	650^0C	60% - 80%	2 MW	Waste water treatment plants.
DMFC	500^0- 1200^0C	40%	1 W- 50 W	Cell phones, laptops, battery chargers.
SOFC	800^0-1000^0C	60%	100KW	Generators for factories and towns
PEMFC	60^0- 80^0C	85%	50KW- 250KW	Vehicles, batteries, commercial buildings and homes.

III. CONCLUSION

The Operating temperature of molten-carbonate, solid-oxide and phosphoric acid FCs is more than PEMFC. Alkaline and direct methanol fuel cells are very expensive. The DOE (Department of Energy) is concentrate on the PEMFC is on the whole useful source intended to application for transportation. The PEMFC has a more energy density and a comparatively small operational temperature extending from sixty to eighty degree Celsius. The low operating temperature helps in warming up of fuel cell during short period of time for generation of electricity.

REFERENCES

[1] C.E.Thomas, "Fuel cell and battery electric vehicles compared", International journal of hydrogen energy, Volume 34, Aug 2009, 6005-6020.

[2] LAUGHTON, "Fuel cells", Engineering science and education journal, Volume 11, Feb 2002, 7-16.

[3] Pragasan pillay, Sold Oxide fuel cell modelling, IEEE transaction on industrial electronics, Volume 56, NOV 18, 139-148.

[4] S.Matsmoto, "Performance model of molten carbonate fuel cell", IEEE transaction on energy conversion, Volume 5, Jun 1990, 252-258.