NET, IAS, State-SET (KSET, WBSET, MPSET, etc.), GATE, CUET, Olympiads etc.: Science and Technology Fuel Cells

Fuel Cells

1. The search for alternative fuels for a sustainable economy and conservation of the environment has brought fuel cell technology to the forefront. A fuel cell creates electric energy by converting a fuel into a negative charge on one terminal and a positive charge on the other terminal. It converts chemical energy of a fuel into electrical energy without the internal combustion steps of a heat engine.
2. Such conversions are possible because the combustion reactions are also redox reactions in nature. That is why a fuel cell uses lightweight but active oxidants and reductants as its fuel. It creates electric energy from a fuel (input on anode side) and an oxidant (input on cathode side) in the presence of an electrolyte. While the electrolyte remains permanently inside the cell, the reactants flow in and byproducts flow out:
3. When a load is connected across a fuel cell the current flows. When it powers a load like car, bus, autorickshaw etc. The fuel is slowly consumed. It works continuously as long as the oxidizing and reducing agents are supplied at the electrodes.
4. A fuel cell does not come under the category of either primary of secondary cell. It differs from a secondary cell in that it cannot be charged in the conventional manner, it is also different from a primary cell in that it consumes reactants that must be replenished continuously and not prepacked.
5. The materials used in fuel cells differ by type because many combinations of fuel and oxidants are possible. The most commonly used fuel cell is the hydrogen cell that uses hydrogen as fuel and oxygen as oxidants. However, a fuel cell does not create any pollution and so can play a leading role in meeting the national goals of clean air, climate protection and energy security.

History of Fuel Cells

1. The principle of the fuel cell was discovered by German scientist Christian Friedrich Schonbein in 1838. He found that a phenomenon opposite to electrolysis of water could create electric energy.
2. The first fuel cell based on this principle was built in 1845 by Welsh scientist Sir William Grove.

Fuel Cell System

1. The hydrogen-oxygen (H2O2) fuel cell has been by far the most successful research in this field. It works on the principle of catalysis, separating the electrons and protons of the reactant fuel at one electrode, and forcing the electrons to travel through a circuit, converting them to electric power. Another catalytic process takes the electrons back to another electrode, combining them with the protons and oxidants to form waste products.

Fuel Cell Design Issues

1. There are several issues related to design of fuel cells that need to be taken care and managed effectively.
    a. Temperature management: In H2O2 fuel cell temperature management is particularly challenging as 2 H2 + O2 = 2 H2O reaction is highly exothermic, so a large quantity of heat is generated within the fuel cell.In order to prevent damage to the cell due to thermal loading the same temperature must be maintained throughout the fuel cell.
    b. Water and air management: In proton exchange membrane fuel cell, the membrane must be hydrated, requiring water to be evaporated at precisely the same rate that it is produced. If the water is evaporated too quickly, the membrane dries, resistance across it increases and eventually will crack, creating a gas short circuit, where hydrogen and oxygen combine directly, generating heat that will damage fuel cell. On the otherhand if water evaporates to slowly, the electrodes will flood, preventing the reactants from reaching the catalyst and stopping the reaction. The management of water in cells is being developed like electroosmotic pumps (osmosis in presence of electric field) focusing on the flow control. Like a combustion engine, a steady ratio between the reactants and oxygen (air) is necessary to keep the fuel cell operating properly.
    c. Activation loss management: In fuel cell, voltage decreases as current increases due to several activation factors. Due to resistance of the cell components and interconnects ohmic loss occurs and voltage drops. Hence, resistance of the fuel cell components needs to be maintained for a steady voltage. Moreover, the depletion of reactants at catalyst sites under high load causes rapid loss of voltage. This is called mass transport loss.

Benefits and Drawbacks

1. Fuel cells are the only technology that can provide pollution free energy for both transportation and electric utilities. Fuel cells are reliable, easy to maintain and safe. They can be fabricated in a wide range of sizes without sacrificing either efficiency or environmental performance. The flexibility allows fuel cells to generate power in efficient manner for automobiles, utilities and buildings.
2. Fuel cells are used as power sources in remote locations, such as spacecraft, remote weather stations, large parks, rural locations and in certain military applications. A fuel

cell system running on hydrogen can be compact and lightweight and has no major moving parts.

3. However, there are certain drawbacks as well. For instance, a single fuel cell only produces approximately 0.7 volts.In order to produce large quantities of electricity, we require many cells. When combined in series if yields higher voltage and when combined in parallel if allows a stronger current to be drawn such a design is called a fuel cell stock. Besides, it is difficult to use hydrogen as fuel due to difficulties of storage and distribution.
4. In India several industries and research organizations are involved in the development of fuel cell. The Defence Research and Development Organization (DRDO) and Reva electric car company jointly displayed the first fuel cell car of India in 2007 and expect the car to reach the mass market soon. The development of Direct Methanol Fuel Cell (DMFC) is also under way at

IISc, Bangalore.

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