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Design of Efficient Flow Field Pattern For Fuel Cell

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Abstract:- A fuel cell is a device that directly transforms the chemical power of fuel into electrical power at a steady temperature. Fuel cells can generate green power for uses ranging from a couple of watts to several megawatts and can run on an array of fuels, including the gas hydrogen, natural gas, and biogas.

***Keywords**:- Fuel Cell, Proton Exchange Membrane, Flow Field.*

I. INTRODUCTION

The overuse of resources derived from fossil fuels as the consequence of increased demand for energy has contributed to air pollution and global warming. Various energy technologies including solar, wind, tidal, geothermal, and fuel cells are being built in order to meet the current need for environmentally friendly green energy.

Chemical procedures in fuel cells yield energy. The usage of batteries made from solid state in industry is presently at its height and is revolutionising how electricity is produced.

The possibility of clean and sustainable power for the entire planet resides with fuel cells that are capable of using hydrogen as a fuel. A fuel cell is an instrument that electrochemically reacts hydrogen and oxygen in water in order to generate heat as well as electricity from hydrogen or an energy source containing hydrogen.

$$2\,H_2\text{ (gas)} + O_2\text{ (gas)} \rightarrow 2\,H_2\text{O} + \text{energy}$$

The production of water and carbon dioxide are the two fundamental responses in the process of combustion of hydrocarbons. The resulting generation of water becomes increasingly apparent as the fuel's hydrogen level expands, which causes a corresponding decrease in emissions of carbon dioxide. Some of the positive aspects of fuel cells are:

- Renewable and ready to use**.**
- It is more efficient than other energy sources.
- Hydrogen is a stable and adaptable energy source that helps support zero carbon energy initiatives.
- More sustainable and energy efficient than fossil fuel.
- Minimizes carbon residue.
- Minimal Noise Pollution

Fuel cells can be found in a variety of shapes and serve a variety of applications. Proton exchange membrane (PEM) fuel cells are the most prominent among them due to their straightforward design, quick start-up time, high energy density, low operating temperature, and minimal environmental effect. The chemical energy generated by the combustion of hydrogen or other fuels is used by proton exchange membrane fuel cells to create electricity clean and inexpensively.

The Membrane Electrode Assembly, or MEA, is the beating system of the PEMFC. It includes of a membrane that resides between the gas diffusion layer (GDL) and the anode and cathode catalyst layer (CL).

In one cell or between two bipolar plates in a PEMFC package, the MEA is positioned between two flow field plates (FFP).

FFP is available as hybrids made of polymer-carbon, polymer-metal, coated or uncoated metal, or porous or impermeable graphite. FFP materials must be affordable, easily fabricated, inert to chemicals, electrically and thermally conductive, and robust physically.

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The flow field equally disperses the reactive gas from the manifold to the active region of each individual primary cell, and the reactant design distributes the reactants in equal amounts to each individual cell.

Therefore, the flow field's main objective is to maintain a minimal pressure drop while uniformly distributing chemicals in the membrane electrode assembly's active catalytic layer through the porous electrode and gas diffusion layer (GDL).

II. LITERATURE REVIEW

D Hart et al.,[1]: This paper provides detailed information on the technology and economics of fuel cells. A device known as a fuel cell uses a temperature-controlled method to transform chemical energy contained in a fuel directly into electric power. This paper helped to learn more about fuel cell technology and objectively discuss the pros and cons of different types of fuel cells. This has helped the project gather information about fuel cells, their pros and cons.

Joseph M. Stanford et al., [2]: The fundamental goals and advancements of fuel cells are the major concerns of the paper. Results on the fuel cell's expenses, efficiency, and longevity are presented, as well as the present condition of hydrogen-related technology. The research shows that one of the most promising approaches for lowering greenhouse gas and oil emissions is the use of fuel cell electric cars (FCEVs). This provided insight into battery performance and the importance of renewable energy. This paper explained the workings of fuel cells in detail.

Mehmet F. Orhan et al.,[3]: In proton exchange membrane fuel cells, this research concentrates mainly on flow fields and flow field plates (bipolar plates). In this regard, an in-depth evaluation of currently available flow field channel configurations has been taken into consideration in addition to the main design restrictions as well as worries for flow field networks. In addition, general materials used in flow field plates and their physical properties were studied. This has helped the project develop materials that can be used in the flow field plates and fuel cells needed to improve performance.

Karrar H. Fahim et al.,[4]: Various configurations and arrangements of flow channels in different designs are proposed in this article, including fins, straight channels, serpentine channels, integral channels, interlocked channels, and channels formed from sheet metal. These different flow field designs have their pros and cons, making them suitable for a wide variety of applications. Improvements in the bipolar plate design can help meet cost and performance targets for commercialization of PEM fuel cells. This helped the project to compare different sheet metal flow field designs.

Taeyoung Kim et al.,[5]: The current research uses physicochemical and electrochemical examination of polyester fabric to show that it may be utilised as a low-cost substitute for Nafion membranes in microbial fuel cells (MFC). As a result, MFC has a higher probability of being used widely. The successful application of MFCs on a big scale is largely dependent on low material costs. Polyester materials can take the place of Nafion, as this paper indicates. This helped the project to find alternatives of membranes to reduce fuel cell cost and maximize performance.

Adriano C. Fernandes et al.,[6]: The efficiency and reliability of a Nafion 212 membrane PEM fuel cell are assessed in this study applying observations of impedance, hydrogen crossover, and single-cell steady-state polarisation. Studies on stability had been carried out while speeding barrier deterioration using the Fenton reaction. Following that, the outcomes are contrasted with those attained using the Nafion 112 membrane. Electrochemical impedance studies were performed to characterize polarization phenomena due to charge transfer kinetics as well as resistive and diffusion effects that degrade cell performance. Two membranes has been compared and this has helped to determine which one is better, more cost effective, and provides the best performance on the general characteristics of PEM fuel cells.

Yue Hung et al., [7]: This study shown that relating the connectors to a steel bipolar plate can enhance the performance of a single cell. Through doing away with additional terminal blocks, this terminal design reduces internal battery resistance. At a current density of 0.30 A/cm2, strong metal contact between the terminals and metal dividers resulted in an 18% improvement in single cell performance and a 15% reduction in hydrogen consumption. However, directly connecting metal terminals in graphite bipolar plates has not shown similar performance improvements to graphite fuel cells, as their fragility can lead to plate damage and poor contacts.. This helped the project in analysing the connection of bipolar plates required for the PEM fuel cell to get maximum efficiency.

Brian Cook et al., [8]: This paper provides a brief introduction to fuel cells, their history, applications, and operation of fuel cells. This paper also discusses the science of fuel cells and the benefits and barriers to their success and the advancement of the hydrogen economy. This has helped the project gain knowledge about fuel cells, fuel cell types, and their pros and cons.

III. WORKING OF PEM FUEL CELL

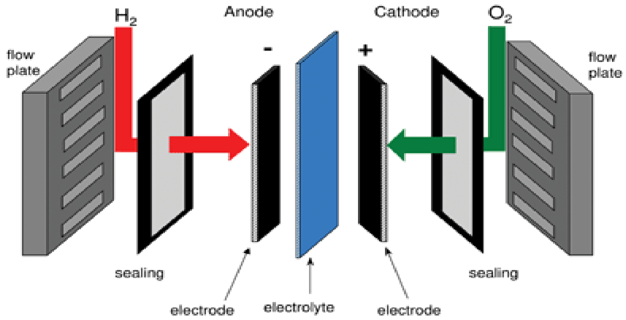

Fig 1 Diagram of a single PEM fuel cell

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In a PEM fuel cell, a process of oxidation at the anode, commonly known as electron loss, and a reaction of reduction at the cathode, also known as electron gain, occur concurrently.

The complete oxidation and reduction procedure, or "redox reaction," that happens in the fuel cell resulting in the generation of water molecules from hydrogen and oxygen gases is made up of both of these processes. The electrolyte that differentiates the anode and cathode, such in an electrolyzer, permits ions to go from one end to the other. In a PEM fuel cell, the solution of electrolyte is a solid form of acid that is aided by the membrane. Water has been absorbed into the solid acid electrolytes to the point of saturation in order permitting the movement of ions. Reaction occurring :

Anode reaction: $H2 \rightarrow 2H+ + 2e-$
Cathode reaction: $½O2 + 2e- + 2H+ \rightarrow H2O$ (l)
Net reaction: $H2 + ½O2 \rightarrow H2O$ (l)

The method through which water is generated from hydrogen and oxygen gases has an exothermic response and an enthalpy of -286 kilojoules of energy per mole of water produced.

With rising temperatures, fewer sources of energy is available to do work. At 25 °C and 1 atm, the amount of energy needed to do work is roughly -237 kJ per mole. Heat and electricity are detected as the outcome of this electrical energy.

The PEM cell uses a type of polymer as its outer layer material. Sheets of large size are usually employed to create PEMs.

Both sides get a coating of electrocatalyst which is trimmed to size. Nafion® is a PEM material that is often employed nowadays. Nafion is a manmade membrane made of Teflon®-like polytetrafluoroethylene, or PTFE, chains, which was created by Dupont in the 1970s.

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