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EXPERIMENTAL ANALYSIS OF GRAPHITE AND METAL FLOW PLATE WITH MULTI HYDROGEN INLET FOR AUTOMOTIVE APPLICATION

Mr. Tamilselvan A[1], Mr. Sethuprabakar M[2], Mr. Madhesh K[3], Mr. Lishanth S[4]

[1] *Assistant Professor, Engineering & Bannari Amman Institute of Technology*

[2] *UG Scholar, Automobile Engineering & Bannari Amman Institute of Technology*

[3] *UG Scholar, Automobile Engineering & Bannari Amman Institute of Technology*

[4] *UG Scholar, Automobile Engineering & Bannari Amman Institute of Technology*

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ABSTRACT:

A comparative study of proton exchange membrane fuel cell with graphite and metal flow plate. A Hydrogen fuel cell is an electrochemical power generator that combines hydrogen and oxygen to produce electricity, with water and heat as by products. Simply put, hydrogen fuel cells form energy that can be used to power anything from commercial vehicles to drones. To evaluate the better flow plate in terms of availability, cost, machining and performance for effective commercialization of proton exchange membrane fuel cell to evaluate the performance deviation of hydrogen fuel cell with Graphite and Metal flow plates. Design and fabricate a hydrogen fuel cell (Proton Exchange Membrane Fuel Cell) with convention serpentine flow field hydrogen and fuel cell activities are presented, focussing on key targets and progress. Recent results on the cost, durability, and performance of fuel cells are discussed, along with the status of hydrogen-related technologies and cross-cutting activities. DOE has deployed fuel cells in key early markets, including backup power and forklifts. Recent analyses show that fuel cell electric vehicles (FCEVs) are among the most promising options to reduce greenhouse gas emissions and petroleum use. Preliminary analysis also indicates that the total cost of ownership of FCEVs will be comparable to other advanced vehicle and fuel option The aim of this report is conception of Hydrogen Fuel Cell Technology. A Hydrogen fuel cell is electrochemical power generator that combines hydrogen oxygen to produce electricity, with water and heat as by products. Simply put, hydrogen fuel cells form energy that can be used to power anything from commercial vehicles to drones.

Keywords**: **Fuel cell, Analysis, Design, Simulation and prototype

I. INTRODUCTION

A Fuel Cell is an electrochemical device that converts chemical energy into electrical energy. The conversion does not involve an intermediate step, thus making a fuel cell a high energy density device and conversion efficiency is much higher than that of any other conventional energy producing devices. It's necessary to shift to alternate source of energy production other than producing energy from conventional form fossil fuels, as depleting source of fossil fuels and strict emission norms. Fuel cell is the most reliable source of clean and green energy production.

1.1 ADVANTAGES OF FUEL CELLS TO IC ENGINES

The present method of power production is from IC engines for both stationary and mobile application. In IC engine the fuel is burnt i.e. chemical energy is converted into heat energy; this heat energy is used to move the pistons i.e. mechanical energy and this mechanical energy is converted into electrical energy with the help of a generator. The conversion of chemical energy into electrical in IC engines involves 3 steps, in each step there are some losses, therefore the conversion efficiency gets reduced. The IC engines emits harmful gases which are to be controlled by separate mechanisms, this leads to increased operating cost. In case of a fuel cell where the chemical energy is directly converted into electrical energy without any intermediate steps, so the conversion efficiency is much higher than IC engines. The reaction in the fuel cell does not gives out any harmful gases, heat and water are the by-product that is formed. So, a fuel cell is a zero-emission energy production device that is most suitable to be used as alternate source of energy production.

1.2 COMPARISON OF FUEL CELL AND BATTERY

Fuel cell and battery have similar construction, i.e. they both have Electrolyte, anode and cathode. Both convert electrochemical reaction directly into electrical energy. The current produced by these two devices are Direct current. Since no moving parts are involved, their operations are quiet.

The operating principle and the structure of fuel cell and battery may be same, but fuel cell needs continuous supply of fuel and oxygen or air for electrochemical reaction to take place.

The battery has these reactants self-built within and they are consumed when the reaction takes place. This is why a battery compared to fuel cell. The fuel cell is a high energy density device.

FIG 1.2 RAGONE CHART

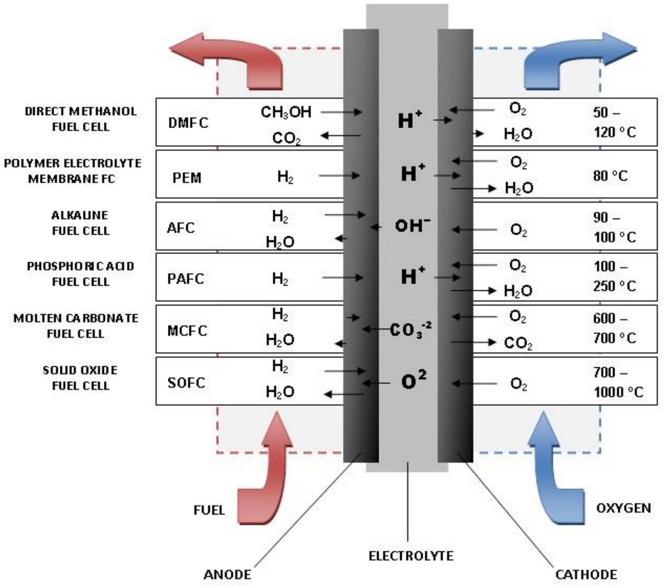

FIG 1.2 RAGONE CHART

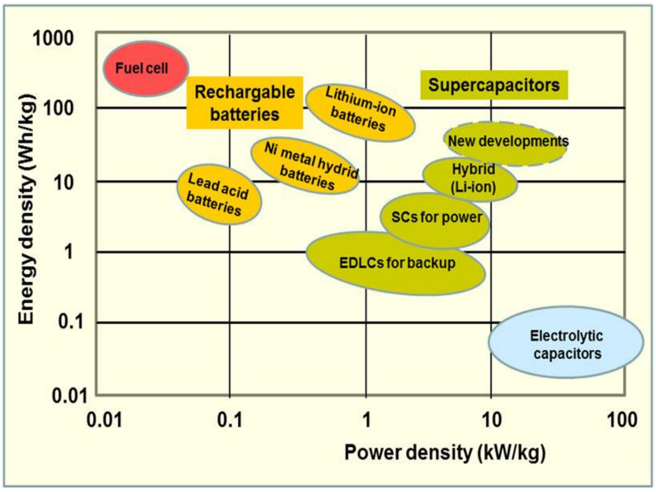

Fig 1.2 compares the power density and energy density of fuel cell, different types of batteries and capacitors. The fuel cells have very high energy density compared to other energy storage device, so fuel cell can be used continuously for long duration that requires high energy. It can't be used for sudden power change like starting a starter motor since the power density of the fuel cell is much lower comparatively.

1.3 TYPES OF FUEL CELL

Fuel cells are classified based on the type of fuel used, electrolyte and operating temperature as alkaline fuel cell (afc), phosphoric acid fuel cell (pafc), proton exchange membrane fuel cell (pemfc), molten carbonate fuel cell (mcfc), direct methanol fuel cell (dmfc) and solid oxide fuel cell (sofc).

FIG 1.3 TYPES OF FUEL CELLS REACTIONS AND OPERATING TEMPERATURE

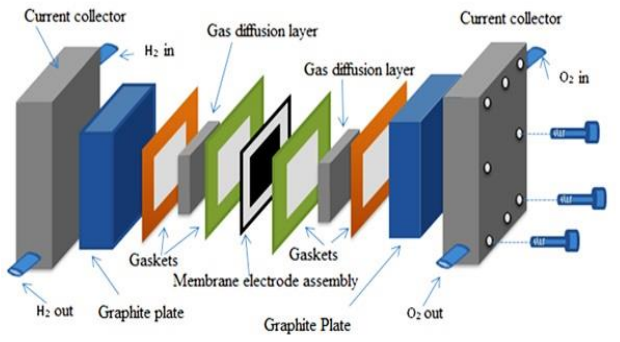

TABLE 1.1 TYPES OF FUEL CELL

Table 1.1 shows the types of fuel cells, their operating temperature range, and electrolyte material used. Based on the operating temperature of PEMFC, which is in the range of 30-100 ℃. PEMFC is best suitable for power production for automotive application.

1.4 PROTON EXCHANGE MEMBRANE FUEL CELL

PEMFCs are low temperature fuel cell operating in within the range of 30-100 ℃ with high efficiency compared to other fuel cells and IC engines. Unlike IC engines and other type of fuel cell there is no emission in PEMFC, Heat and water are produced as by-product along with electricity generation. There are no moving parts in PEMFC, so they are quite in operation. Moreover PEMFC is environmental friendly energy production device with suitable transient response characteristics.

1.5 STRUCTURE OF PEMFC

The PEMFC consists of anode graphite plate over which the flow field is engraved, anode GDL, MEA, cathode GDL and cathode graphite plate with flow field. In PEMFC the anode is negative in which Hydrogen is passed and cathode is positive in which Oxygen is passed. The MEA has 3 layers namely anode catalytic layer, Proton Exchange Membrane and cathode catalytic layer. The PEM layer is made of Perflurosulfonic acid which conducts the proton but not the electrons. On either side of the graphite plate current collectors are installed which collects the current produced and delivers it to the outer circuit, in some cases graphite plate itself acts as current collector. The current collector is Copper plate coated with Gold. To support the entire structure of the fuel cell Aluminium plates are used at the extreme end. The structure of the fuel cell is shown in Fig

The noble materials such as platinum or ruthenium is used as catalyst. Hydrogen oxidation reaction and oxygen reduction reaction are induced by catalyst. The catalyst being a noble metal is very costly. Platinum is coated over carbon which is a supporting material. The GDL is made of carbon cloth or carbon

FIG 1.4 EXPLODED VIEW OF A SINGLE PEMFC

Uniformly distribute the reactant throughout the catalytic layer on anode and cathode side. GDL has high heat and electrical conductivity. The flow fields are used to carry the reactants to cell through different flow pattern. The water formed in the cathode corrodes the metal flow field resulting in poor electrical conductivity. Graphite being impermeable to water and has less electrical resistivity been used as flow filed plate and also for its less weight nature.

1.6 MEMBRANE

The main function of the membrane in PEM fuel cell is to transport protons from the anode to the cathode: membrane polymers have sulfonic groups, which facilitate the transport of protons. The other function includes keeping the fuel and oxidant separated, which prevents mixing of the two gases and withstanding harsh conditions, including active catalysts, high temperatures or temperature fluctuations, strong oxidants and reactive radicals. Thus, the ideal polymer must have excellent proton conductivity, chemical and thermal stability, strength, flexibility, low gas permeability, low water drags, low cost and good availability. Different types of membranes have been tested for use in PEM fuel cells. Fig 1.5 shows the membranes coated with platinum catalyst. One of the most widely used

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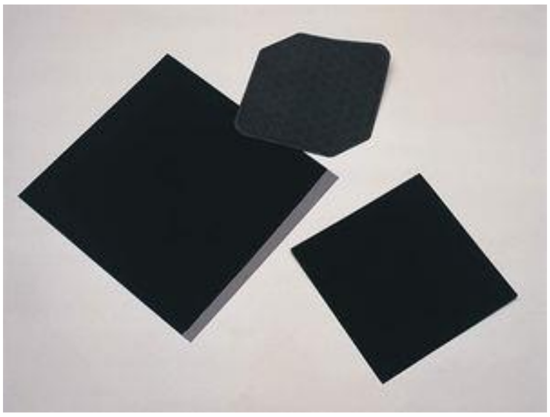
membranes today is Nafion, a polymer created by the DuPont company. Nafion has an aliphatic per fluorinated backbone with ether-linked side chain ending in sulfonate cation exchange sites. It is a copolymer of tetrafluoroethylene and sulfonic fluoride vinyl ether and has a semi-crystalline structure. This structure, which resembles Teflon, gives Nafion long term stability in oxidative or reductive conditions.

FIG 1.5 MEMBRANE COATED WITH PLATINUM CATALYST

1.7 CATALYST LAYER

Platinum has been considered to be the best catalyst for both the anode and the cathode though there is a large difference between the Oxygen oxidation



reaction (ORR) and the Hydrogen oxidation reaction (HOR) using the same catalyst. A great deal of effort has been made by many researchers towards developing appropriate catalyst material, especially for the ORR and platinum is so for still best option. In conventional method the platinum catalyst is formed into small particles on a surface of somewhat larger particles that act as a supporter, known as carbon powder. A widely used carbon based powder is Vulcan XC72R. This way the platinum is highly divided and

spread out, so that a very high proportion of the surface area will be in contact with the reactant resulting in a great reduction of the catalyst loading with an increase in power. In conventional method the platinum is applied to the Gas diffusion layer (GDL) and then to the membrane.

1.5 WORKING PRINCIPLE OF PEMFC

Hydrogen of high purity is passed through anode and oxygen is passed through cathode. The Hydrogen oxidation reaction is carried out in anode side, splitting H_2 into protons H^+ and electrons e^- as shown in equation 1.1. The Proton exchange membrane allows only protons to pass through blocking the gases. The oxygen reduction reaction takes place in the cathode side as shown in equation 1.2. The electrons produced by the hydrogen oxidation reaction flows through the external circuit from anode to cathode. In cathode the H^+ protons and e^- electrons combines with oxygen to give water as shown in equation 1.3.

Anode reaction $H_2 \rightarrow H^+ + 2e^-$ …………………………………..…...….(1.1)

Cathode reaction $2H^+ + 2e^- + \frac{1}{2}O_2 \rightarrow H_2O$ ………...……………….....….(1.2)

Overall reaction $H_2 + \frac{1}{2}O_2 \rightarrow H_2O + Electricity + Heat$ ……..(1.3)

CHAPTER – 2

2.1 ITERATURE SURVEY

A 10 KW class fuel cell stack based on the catalytic coated membrane method- Mingruo Hu, Sheng Sui, Xinjian Zhu, Qinchun Yu, Guangyi Cao, Xueying Hong, Hengyong Tu.

A 60 cell 10 kW class PEM fuel cell stack has been developed and tested. By using the catalyst coated membrane method, a power density

of 0.36 W/cm^2 was reached for a single cell with a 600 cm^2 active area. The total Pt loading was 0.6 mg/cm^2 for the anode and cathode catalyst layers. Cyclic voltammogram (CV) tests revealed that the CCM method had a higher Pt utilization when compared to the hydrophobic method. Furthermore, a maximum power of 10.9 kW was reached at an air utilization of 30 %. A 400-hour performance test showed a 2 V fluctuation of the stack voltages.

Coupling the 10-kW class stack with an external humidifier gave a relatively poor power of 6 kW.

1. A study on scaled up proton exchange membrane fuel cell with various channels for optimizing power output by effective water management using numerical technique - S. Arun Saco, R. Thundil Karuppa Raj, P. Karthikeyan.

In this paper, an extensive numerical study is carried out for optimizing the flow channels with respect to optimal pressure drop and water management for the scaled up model of PEMFC. This involves four different configuration of flow channel for 25 cm^2 is extended to 225 cm^2 area. It is found that the power density developed by straight flow channel with zig-zag flow path is 0.3758 W/cm^2 and is the maximum of the configuration considered.

Experimental investigation on scaling and stacking up of PEM fuel cells - P. Karthikeyan, P. Velmurugan, Abby Joseph George, R. Ram Kumar, R.J. Vasanth.

The performance of a PEMFC with various flow channel design (serpentine and interdigitated) with different landing to channel ratios (L:C - 1:1, 2:2) for an active area of 25 cm^2 and 70 cm^2, for two cell stack is studied and compared. This study establishes a strong relation between back pressure and power output from a PEMFC. The effect of cooling channels with natural and forced convection by using induced draught fan on the performance of a PEMFC stack is also studied. Fuel distribution and temperature management are found to be the significant factors which determine the performance of a PEMFC stack.

Experimental investigation on uniform and zig-zag positioned porous inserts on the rib surface of cathode flow channel for performance enhancement in PEMFC - P. Karthikeyan, R.J. Vasanth, M. Muthukumar

The performance of a PEMFC with serpentine flow channel in cathode and 2mm porous inserts positioned on rib in uniform and zig-zag pattern is considered for this study. It is noted that the zig-zag shows increased performance than the normal and uniform flow pattern. The influence of porosity of carbon inserts on the cell performance is also studied by varying the porosity of carbon inserts in the range of 60-70 %, 70-80 %, 80-90 % respectively. The results show that the flow channel with zigzag positioned porous inserts having 80-90 % porosity has improved the power density of 0.270 W/cm^2.

5. Numerical Studies on PEM Fuel Cell with Different Landing to Channel

6. Width of Flow Channel - M.Muthukumar, P.Karthikeyan, M.Vairavel, C.Loganathan, S.Praveenkumar, A.P.Senthil Kumar

The performance of the fuel cell is highly influenced by the operating parameters like temperature, pressure, humidity and mass flow rates of reactant gases; and the design parameters like flow channel designs and dimensions, rib size, channel length, thickness and porosity of GDL, membrane type etc. In this paper, the effects of different Landing to Channel (LxC) width of flow channel were studied numerically. The full three-dimensional models of a proton exchange membrane fuel cell have been developed with a constant channel length of 20 mm and with different Landing to Channel width (LxC) in mm of 0.5x0.5, 1x1, 1.5x1.5, 2x2.From the results, it was found that the PEMFC with landing to channel width of 0.5x0.5 mm has generated a high current density and high power density compared to other three designs. Also it was found that the smaller width of landing and channels are required for high current density and power density outputs of the PEMFC due to the better water management.

CHAPTER-3
METHODOLOGY (RESEARCH DESIGN & METHODS)

3.1 FUEL SYSTEM MODEL: ANALYSIS AND SIMULATION

A literature review was conducted to identify the problems and objectives. The identified problems are deeply analysed to find a suitable solution. Feasibility study is conducted for developing a cost-effective model.

The 3D model of the fuel cell is done using NX 10.0. The major problem in scaling is cathode flooding. An optimum moisture content is to be maintained over the GDL for efficient performance of PEMFC. Finally, a real time model is created and performance characteristics are experimentally verified.

To remove the water formed in between the interface of the GDL and the rib of the cathode, porous inserts are introduced on the cathode rib to absorb the excess water content.

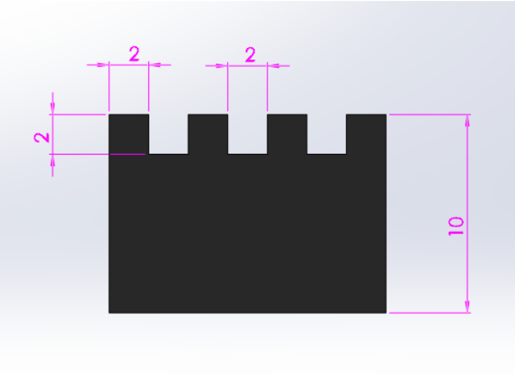
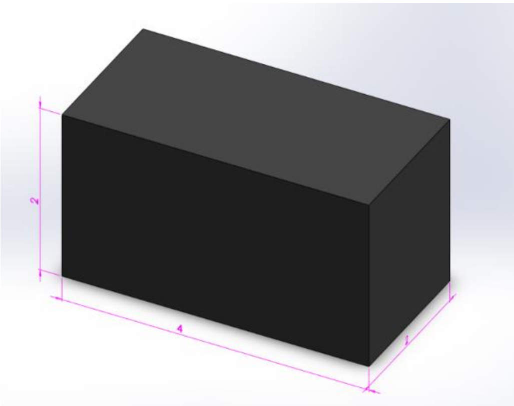
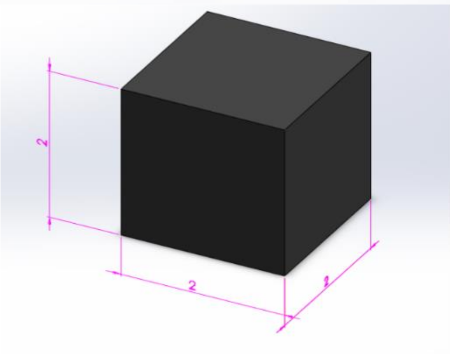


FIG 4.1 CROSS SECTION OF SERPENTINE FLOW FIELD USED AT ANODE

Fig 4.1 shows L:C:H: 2:2:2 mm and the thickness if the graphite plate used is 10 mm. Based on the literature review, numerical and experimentation results shows that Serpentine with L:C 2:2 shows higher performance compared to other flow fields. The overall cell efficiency is increased by effectively transporting the water within the cell.
Hence for this work serpentine with L:C 2:2 has been selected as anode flow field.

4.3 PROCESS FLOW





1. Machining of flow fields with different flow flow field design like serpentine, serpentine with uniform and zig-zag pattern of active area 25 cm^2 and 36 cm^2.
2. Fabrication of porous inserts of required size (L x B x H: 2 mm x 2mm x 2mm and 4 mm x 2 mm x 2 mm) using vulcan carbon of porosity 80 to 90 % porosity.
3. Experimental studies on 25 cm^2 PEMFC with serpentine flow field, serpentine with 4 mm porous inserts arranged in uniform and zig-zag pattern is conducted.
4. Scaled up model PEMFC with active area 36 cm^2 is studied with serpentine flow field, serpentine with 2mm and 4 mm porous inserts arranged in uniform and zig-zag pattern is conducted.
5. Comparing the performance of 25 cm^2 and 36 cm^2 active area with and without porous inserts on cathode flow field to analyse the water removal capability.

DESIGN OF 25 cm^2 SERPENTINE FLOW CHANNEL WITH 4 mm POROUS INSERTS - UNIFORM PATTERN

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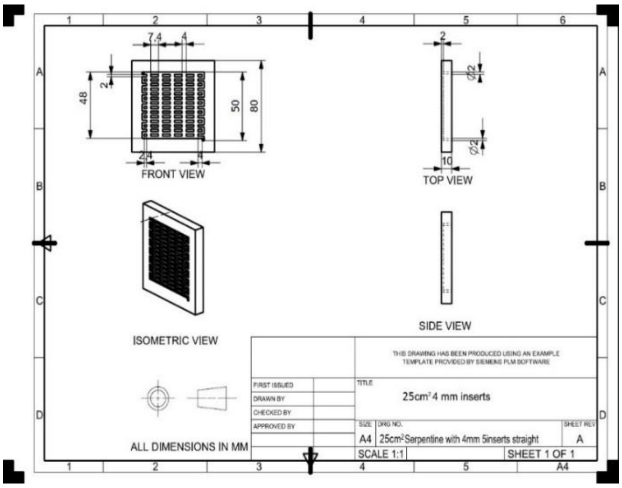

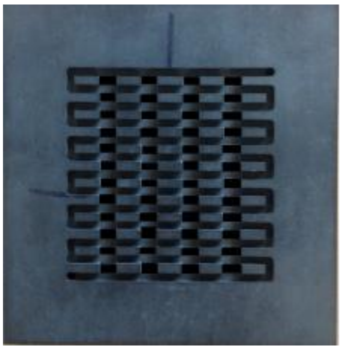

FIG 5.1 SERPENTINE WITH UNIFORM FLOW PATTERN

Fig 5.1 shows the cathode flow field with provisions for 4 mm porous inserts arranged in uniform pattern. The land to channel ratio is 2:2 with active area 25 cm^2 and depth of the flow channel is 2 mm. In this design 5 porous inserts can be inserted in each land as shown in fig 5.2

5.2 DESIGN OF 25 cm^2 SERPENTINE FLOW CHANNEL WITH 4 mm POROUS INSERTS - ZIG-ZAG PATTERN

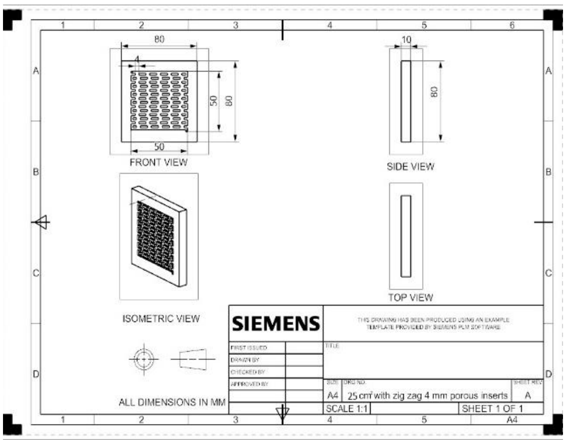

FIG 5.3 SERPENTINE WITH ZIG-ZAG FLOW PATTERN

Fig 5.3 shows the cathode flow field with provisions for 4 mm porous inserts arranged in zig-zag pattern. The land to channel ratio is 2:2 with active area 25 cm^2 and depth of the flow channel is 2 mm. In this design 5 porous inserts can be inserted in each land.

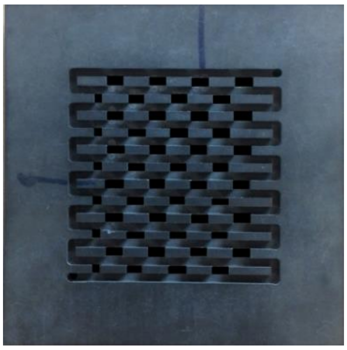

FIG 5.4 25 CM^2 SERPENTINE FLOW FIELD WITH 4 MM POROUS INSERTS - ZIG-ZAG PATTERN

Fig 5.4 shows the porous inserts arranged in zig-zag manner on the provision made in cathode landing. This is a altered form of serpentine flow channel with 4 mm x 2 mm x 2 mm inserts on it for absorbing water that is formed between the cathode landing and MEA.

5.3 DESIGN OF 36 cm^2 SERPENTINE FLOW CHANNEL

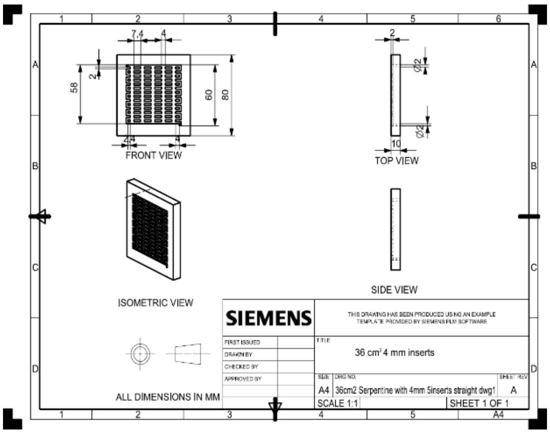

FIG 5.5 SERPENTINE WITH UNIFORM FLOW PATTERN

Fig 5.5 shows the cathode flow field with provisions for 4 mm porous inserts arranged in uniform pattern. The land to channel ratio is 2:2 with active area 36 cm^2 and depth of the flow channel is 2 mm. In this design 5 porous inserts can be inserted in each land.

FIG 5.6 36 CM^2 SERPENTINE FLOW FIELD WITH 4 MM POROUS INSERTS - UNIFORM PATTERN

Fig 5.6 shows the porous inserts arranged in uniform manner on the provision made in cathode landing. This is a altered form of serpentine flow channel with 4 mm x 2 mm x 2 mm inserts on it for absorbing water that is formed between the cathode landing and MEA.

5.4 DESIGN OF 36 CM^2 SERPENTINE FLOW CHANNEL WITH 4 MM POROUS INSERTS - ZIG-ZAG PATTERN

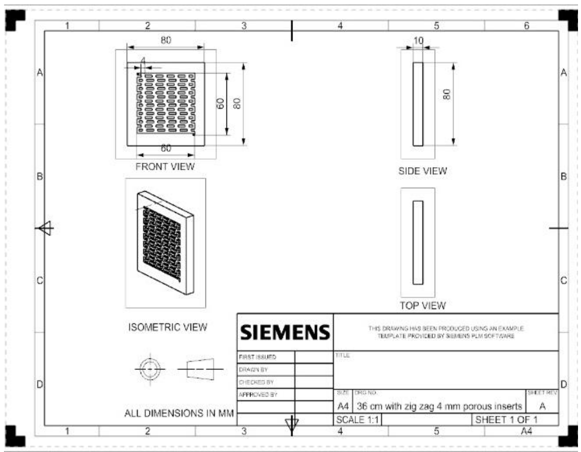

FIG 5.7 SERPENTINE WITH ZIG-ZAG FLOW PATTERN

Fig 5.7 shows the cathode flow field with provisions for 4 mm porous inserts arranged in zig-zag pattern. The land to channel ratio is 2:2 with active area 36 cm^2 and depth of the flow channel is 2 mm. In this design 5 porous inserts can be inserted in each land.

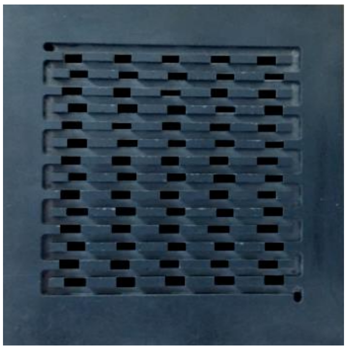

FIG 5.8 36 CM^2 SERPENTINE FLOW FIELD WITH 4 MM POROUS INSERTS - ZIG-ZAG PATTERN

Fig 5.8 shows the porous inserts arranged in zig-zag manner on the provision made in cathode landing. This is an altered form of serpentine flow channel with 4 mm x 2 mm x 2 mm inserts on it for absorbing water that is formed between the cathode landing and MEA.

CHAPTER-4

RESULT AND DISCUSSION

7.1 PERFORMANCE CHARACTERISTICS OF 25 cm^2

7.1.1 Performance characteristics of 25 cm^2 fuel cell with 4 mm porous inserts-uniform pattern

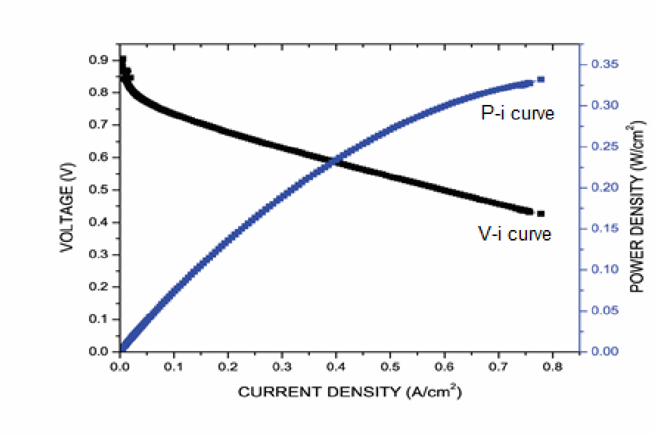

Fig 7.1 25 cm^2 Serpentine with 4 mm porous inserts - Uniform pattern

Fig 7.1 shows the performance curve of 25 cm^2 PEMFC with 4 mm porous inserts arranged in uniform pattern. The peak power density is 0.332 W/cm^2 and peak current density is 0.778 A/cm^2. The increase in power density is 37.19 % and increase in current density is 15.08 % when compared with normal serpentine flow field.

When compared with serpentine flow field with 2 mm porous inserts - uniform pattern the increase in power density is 25.28 % and increase in current density is 4.01 %. When compared with serpentine with 2 mm porous inserts - zig-zag pattern the increase in power density is 22.96 % and increase in current density is 7.45 %.

7.1.2 PERFORMANCE CHARACTERISTICS OF 25 CM^2 FUEL CELL WITH 4 MM POROUS INSERTS- ZIG-ZAG PATTERN

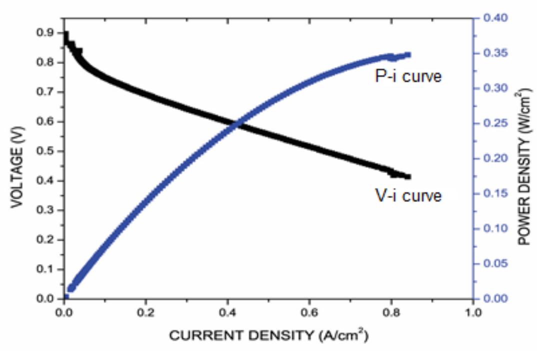

Fig 7.2 25 cm^2 Serpentine with 4 mm porous inserts - Zig-zag pattern

Fig 7.2 shows the performance curve of 25 cm^2 PEMFC with 4 mm porous inserts arranged in zig-zag pattern. The peak power density is 0.348 W/cm^2 and peak current density is 0.839 A/cm^2. The increase in power density is 43.80 % and increase in current density is 24.11 % when compared with normal serpentine flow field.

When compared with serpentine with 2 mm porous insert - uniform pattern the increase in power density is 31.32 % and increase in current density is 12.16 %. The percentage increase in power density when compared with serpentine with 2 mm porous inserts - zig-zag pattern is 28.89 % and current density is 15.88 %.

4.82 % increase in power density and 7.84 % increase in current density is observed when compared with serpentine with 4 mm porous inserts - uniform pattern. From the results it’s clear that the porous inserts of size 4 mm arranged in zig-zag pattern effectively removes water formed between the cathode landing and MEA.

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7.2 PERFORMANCE CHARACTERISTICS OF 36 cm^2

7.2.1 PERFORMANCE CHARACTERISTICS OF 36 CM^2 FUEL CELL SERPENTINE FLOW FIELD

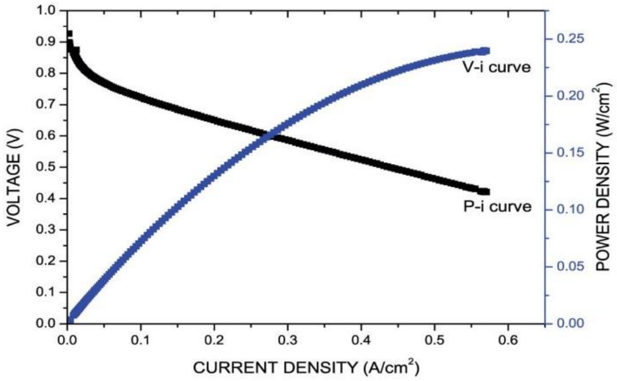

FIG 7.3 36 CM^2 NORMAL SERPENTINE FLOW FIELD

Fig 7.3 shows the performance curve of 36 cm^2 PEMFC normal serpentine flow field. The peak power density is 0.2398 W/cm^2 and peak current density is 0.5701 A/cm^2. There is a decrease in power density in the scaled-up model, the decrease percentage is 1.12 % when compared with 25 cm^2 PEMFC with normal serpentine flow field.

The decrease in performance of the PEMFC may be due to the water formed between the MEA and cathode landing is not removed by the reactants, uneven distribution of the reactants. The drop in performance of the PEMFC due to flooding in cathode is rectified by positioning porous insert on cathode landing in uniform and zig-zag pattern. For this study porous inserts of two various sizes are taken, they are 2 mm x 2 mm x 2 mm and 4 mm x 2 mm x 2 mm.

The influence of these porous inserts on the performance of the PEMFC is discussed in the following results.

7.2.2 PERFORMANCE CHARACTERISTICS OF 36 CM^2 FUEL CELL WITH 2 MM POROUS INSERTS-UNIFORM PATTERN

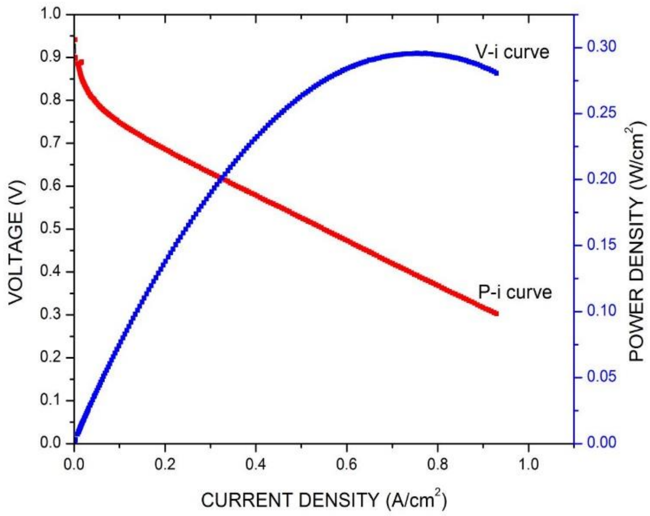

FIG 7.4 36 CM^2 SERPENTINE WITH 2 MM POROUS INSERTS - UNIFORM PATTERN

Fig 7.4 shows the performance curve of 36 cm^2 PEMFC with 2 mm porous inserts arranged in uniform pattern. The peak power density is 0.2956 W/cm^2 and peak current density is 0.7321 A/cm^2. The increase in power density is 23.69 % and current density is 28.42 % compared with 36 cm^2 serpentine flow field.

Form the result it's inferred that the porous inserts positioned on the cathode land in uniform pattern absorbs the water formed between MEA and cathode landing.

7.2.3 PERFORMANCE CHARACTERISTICS OF 36 CM^2 FUEL CELL WITH 2 MM POROUS INSERTS-ZIG-ZAG PATTERN

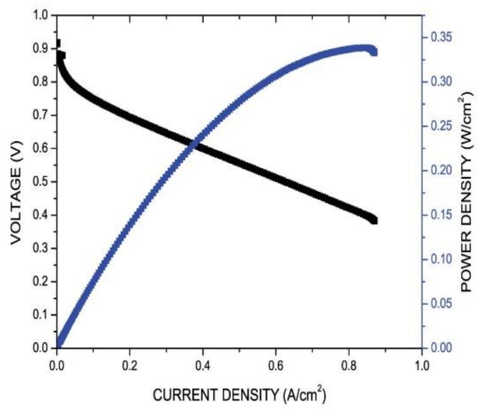

Fig 7.5 36 cm^2 Serpentine with 2 mm porous inserts - zig-zag pattern

Fig 7.5 shows the performance curve of 36 cm^2 PEMFC with 2 mm porous inserts arranged in zig-zag pattern. The peak power density is 0.3386 W/cm^2 and peak current density is 0.8711 A/cm^2. The increase in power density is 41.20 % and current density is 52.80 % compared with 36 cm^2 serpentine flow field.

When compared with serpentine with 2 mm porous inserts - uniform pattern, increase in power density is 14.54 % and increase in current density 18.99 % is obtained. The decrease in power density due to scaling up is reduced.

7.2.4 PERFORMANCE CHARACTERISTICS OF 36 CM^2 FUEL CELL WITH 4 MM POROUS INSERTS-ZIG-ZAG PATTERN

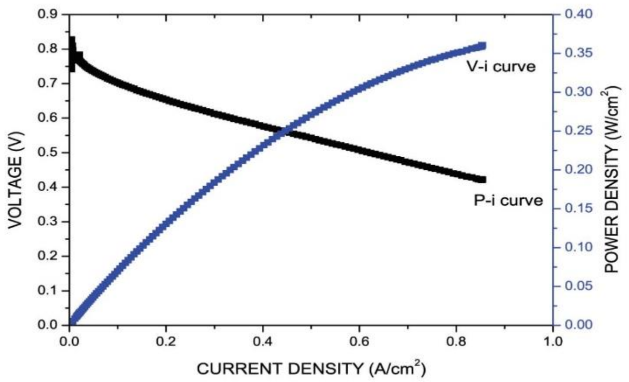

Fig 7.6 36 cm^2 Serpentine with 4 mm porous inserts - zig-zag pattern

Fig 7.6 shows the performance curve of 36 cm^2 PEMFC with 4 mm porous inserts arranged in zig-zag pattern. The peak power density is 0.3604 W/cm^2 and peak current density is 0.8541 A/cm^2. The increase in power density is 50.34 % compared with 36 cm^2 serpentine flow field.

When compared with serpentine with 2 mm porous inserts - uniform pattern, the increase in power density is 21.2 % and increase in current density is 16.66 %.

6.47 % increase in power density is observed when compared with serpentine with 4 mm porous inserts - zig-zag pattern. This shows that the porous inserts positioned on the cathode land in zig-zag pattern absorbs water more efficient than other flow fields.

CHAPTER-5
CONCLUCTION

8.1 PRESENT WORK'S CONCLUSION

Scaling up studies from 25 cm^2 to 36 cm^2 PEMFC with various flow field design like serpentine, serpentine with porous carbon inserts arranged in uniform and zig-zag pattern on cathode side have been conducted.

Performance studies on 25 cm^2 and 36 cm^2 PEMFC with various flow field have concluded that serpentine with porous carbon inserts arranged in zig-zag pattern shows better performance than other flow fields.

Comparing serpentine flow field with serpentine with 4 mm inserts-uniform and zig-zag pattern for 25 cm^2 shows increase in power density of 37.20 % and 43.80 % respectively.

Comparing serpentine flow field with serpentine with 2 mm inserts-uniform and zig-zag pattern for 36 cm^2 shows increase in power density of 23.27 % and 41.20 % respectively.

Comparing serpentine flow field with serpentine and serpentine with 2 mm porous inserts in uniform and zig-zag pattern with 4 mm inserts - zig-zag pattern for 36 cm^2 shows increase in power density of 50.34 %, 21.20 % and 6.47 % respectively.

The insertion of porous carbon inserts has a great effect on overall performance of PEMFC. The flooding in cathode side is greatly reduced due to efficient water conduction by the porous inserts. The experimental results also shows the performance has

increased. The flooding in scaling up of PEMFC can be reduced by insertion of porous inserts.
When the active area of a PMFC is scaled up there is a drop in power density, this drop has also been reduced by insertion of porous inserts. This is due to water removal by positioning the porous inserts on the cathode landing.

FUTURE WORK

In this present work porous inserts of size 2 mm and 4 mm positioned on cathode landing in uniform and zig-zag pattern have been experimentally
tested. The future work will be on increasing the size of the porous inserts to 6 mm. For further clarity of influence of porous carbon inserts on performance of PEMFC, experimentation is to be conducted to check whether the peak performance lies between 2 mm and 4 mm. The successful completion of this project will lead to commercialization of the product.

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