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Format for Submission of Proposal for Minor Research Project

PART-A

Broad Subject: Hydrogen Fuel Cells

Area of Specialization: **Polymer Electrolyte Membrane Fuel Cell (PEMFC)**

Duration: **1½ Year**

Principal Investigator:

Name: **Dr. Virendra Bhojwani**

Sex: **Male**

Date of Birth: **30th July 1978**

Qualification: **Ph.D. Mechanical Engineering (IIT Bombay)**

Designation: **Director, R&D & President IIC-MITADTU**

Address: **6th Floor, R&D Cell Office, MIT ADT University, Pune**

Name of Department/Institution: **Research & Development Cell**

Teaching Experience: **12 Years**

Research Experience: **10.5 Years**

Paper Publications:

Published: **55**

Accepted: **51**

Communicated: **04**

* Research papers published in last 5 years.

Book Publication

Published: **02**

Accepted: **02**

Communicated: **01**

1
(Kindly **enclose the list of papers and books published and accepted during last five years**)

Co - Principal Investigator:

Name: **Mr. Mandar Patunkar**

Sex: **Male**

Date of Birth: **15th September 1985**

Qualification: **M.E. (Manufacturing Engineering)**

Designation: **Research Associate, Research & Development Cell**

Address: **6th Floor, R&D Cell Office, MIT ADT University, Pune**

Name of Department/Institution: **Research & Development Cell**

Teaching Experience: **12 Years**

Research Experience: **2.5 Years**

Paper Publications:

Published: **Nil**

Accepted: **Nil**

Communicated: **Nil**

Book Publication

Published: **Nil**

Accepted: **Nil**

Communicated: **Nil**

PART-B

Proposed Research Work

❖ **Project Title:**

Investigate the scope and performance of Nickel based GDL in Single PEM Fuel Cell

❖ **Introduction:**

Today the world needs an energy source which is clean, environment friendly, efficient, portable and compatible with respect to energy demand. This all requirements can be satisfied with the help of Fuel Cells. Fuel Cells are basically the electro chemical device which produces the electricity by using Hydrogen as a fuel and Oxygen as a reactant and carrying out its chemical reaction with suitable materials.

Especially the PEM based Fuel Cells have various applications in the era of transportation, portable devices, material handling, stationary devices, energy services. These fuel cells are unique and compatible with wide range of fuels and categorized on the basis of electrolyte used in them. A fuel cell is made up of majorly with two electrodes (anode and cathode) and electrolyte, which separates the two electrodes. A fuel cell uses Hydrogen as a fuel where hydrogen splits in to the ions and electrons at the anode. Electrons are carried out externally to produce the electricity where as ions of hydrogen are allowed to pass through the electrolyte. This ion of hydrogen, electrons and oxygen reacts together at cathode resulting in producing the vapors of water and heat as output of fuel cells.

Fuel cells are considered as a clean and efficient device to generate the electricity after renewable energy sources. One can say that fuel cell is an electrochemical device which is a similar concept of a battery where execution of chemical energy is done in order to produce electricity. In fuel cell hydrogen is the fuel, and only products those are released in environment are electricity, water, and heat. Hence no pollution and carbon products are produced and contribute to the de-carbonization of the world. Therefore Fuel cells can be seen as promising power producing devices which marginally suitable with respect to battery operated devices and equipments.

❖ **Objectives:**

- 1) Design and Develop the Single PEM Fuel cell with 2.5cm X 2.5cm of Nafion Membrane and Carbon Paper as a GDL with 20% loading on Pt/C.
- 2) Design and Manufacture the Nickel based GDL of size 2.5cm X 2.5cm and comparing it with steel SS304.

- 3) Optimize and check the results for its porosity and thickness of GDL also compare the results of Nickel mesh and check for the performance.

❖ **Methodology:**

In order to achieve the objectives, fuel cell needs to be incorporating with two different GDL SS304 and Nickel. Size of the Nafion membrane, GDL, current collector will be 2.5cm X 2.5cm. Size of the fuel cell is based on the past literature survey and Nafion is used as Proton Exchange Membrane for the fuel cell. This assembly of fuel cell is expected to generate 1.5 Volts as OCV. As shown in figure below fuel cell contains the two electrodes with Membrane Electrode Assembly (MEA) at the centre. This MEA is the heart of Fuel Cell which is comprises of electrode, catalyst and proton exchange membrane together. Electrodes are made up of Carbon Paper with approx 0.3mm thick and 77% porosity. This carbon electrode is loaded with 20% Pt/C powder in order to work as catalyst. Nafion membrane is sandwiched between these two electrodes. The arrangement can be seen in the figure below. Experiments will be carried out to find out the effect on performance and scope of GDL of SS304 steel and Nickel mesh. Finally the results will be compared and optimized.

The arrangement of Fuel Cell is shown as below where two electrodes are known as Anode and Cathode and are located at two ends of fuel cell. These two electrodes are separated by membrane. This membrane is usually a PTFE (Polytetrafluoroethylene) and Teflon coated in order to achieve the hydrophobic and hydrophilic effects on cathode and anode side respectively. Both the electrodes are connected externally for electricity generation.

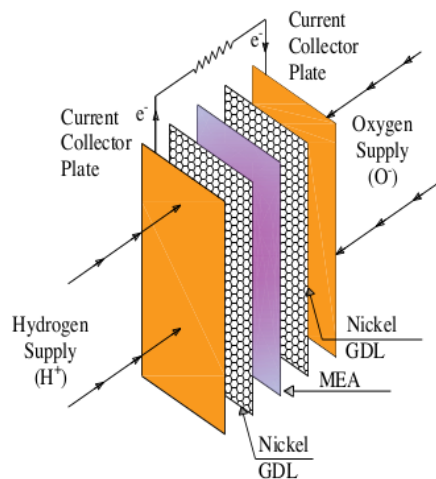


Fig. Fuel Cell with Nickel as Gas Diffusion Layer (GDL)

Hydrogen is supply to Anode at this location HRR (Hydrogen Reduction Reaction) reaction takes place where as ORR (Oxygen Reduction Reaction) takes place at Cathode. During the ionization of hydrogen at HRR, Hydrogen ions get separated from electrons and only hydrogen is allowed to transfer through Nafion Membrane. Electrons can be passed to the external circuit from where the electricity can be generated. This positively charge hydrogen ion goes to Cathode where they again get reacted with oxygen supply to Cathode and electrons transfer from the external circuit. Hence, as a output at the cathode side water vapour is produced and heat is generated. This way the clean and environment friendly energy can be produced and small portable devices can be run on the basis of this.

❖ **Financial Assistance required**

Item	Estimated Expenditure
Books and Journals	10,000/-
Minor equipment/software, if needed	1,20,000/-
Field work & travel support (within India)	85,000/-
Consumables (ICs, circuit board, chemicals, data, tools, testing charges etc.) if any	2,50,000/-
Contingency	35,000/-
Any other item with prior approval of faculty Dean of respective institution	---
Total	5,00,000/-

Following are the details of above mentioned finance:-

Sr. No.	Name of Item	Specification / Specific Details	Supplier / Organization	Cost in Rs.
❖ Books & Journals				
1	Books, Journals and Research Papers	Fuel Cells & Hydrogen Production Process	Elsevier, Springer, Willis, Natures and other Publications	10,000/-
Total				10,000/-
* This research materials available mainly in the hard copy as well as soft copy				

Sr. No.	Name of Item	Specification / Specific Details	Supplier / Organization	Cost in Rs.
❖ Minor Equipment and Software if needed				
1	COMSOL 6.0	Multiphysics software	COMSOL	30,000/-
2	Single Fuel Cell Test Rig Setup	PEM Fuel Cell 2.5cm X 2.5cm for generating approx. 1.5 to 2 OCV	Laboratory Made	90,000/-
Total				1,20,000/-

Sr. No.	Name of Item	Specification / Specific Details	Supplier / Organization	Cost in Rs.
❖ Field work & travel support (within India)				
1	Fuel Cell Laboratory or Research Laboratory	Research Testing Facility and Labs	IIT Madras or NCL or ARCI Hyderabad	25,000/-
2	International Conference	Presenting and Publishing Research Papers and Work	--	20,000/-
3	SEM and XRD	Scientific Equipments & Testing	CIF, SPPU	40,000/-
4	SEM with EDS facility	Scientific Equipments & Testing	College of Engineering, COEP, Pune	
5	Atomic Microscope and OCV Measuring Facility	Scientific Equipments & Testing	Agharkar Research Institute	
6	Single Crystal XRD and Cyclic Voltametry	Scientific Equipments & Testing	National Chemical Laboratory	
Total				85,000/-

❖	Consumables (ICs, circuit board, chemicals, data, tools, testing charges etc.) if any			
Sr. No.	Name of Item	Specification / Specific Details	Supplier / Organization	Cost in Rs.
1	Nafion Membrane	Nafion 117 Membrane (100mm x 100mm)	DTech Solutions, IIT Kanpur	7,500/-
2	D520 Nafion Solution 10ml	Alcohol based 1000 EW at 5 wt%	DTech Solutions, IIT Kanpur	5,650/-
3	Carbon Paper similar to (Avcarb T-50)	Thickness: 0.31mm Basic Weight: 80g/m ² Air Permeability: <10sec Through-Plane, Porosity: 77%	DTech Solutions, IIT Kanpur	7,500/-
4	Pt/C Catalyst	20 wt% Pt/C, 5gm	HADES Global, Gujrat (1950/-* Rs per gram)	19,500/-
5	Aluminum Plate	350mm x 350mm, 12mm thk, 3.5kg	Shah Metal Merchant	3,350/-
6	Silicon Gaskets & Bonding Materials	1ft x 1ft (1mm thk & 2mm thk)	Excel Trading Corporation	5,000/-
9	PE Sheet	4ft x 3ft	Excel Trading Corporation	2,000/-
10	Copper Plate	Current Collector, (3ft x 3ft x 1mm) x 2kg	Shah Trading or other	4,800/-
11	SS304 steel Mesh	3 types Large, Medium and Micro Strands (2.5ft x 2.5ft)	Zain Corporation	1,664/-
12	Gas Pipe Connector	Pneumatic with M6 and lower diam.	Hind pneumatics	950/-
13	HHO Generator	For producing hydrogen	In-house produce	20,500/-
14	Carbon Black	Vulcan XC-72R	10gm (960/-* Rs per gram)	25,000/-
15	Glycerol	Solvent 1litre	Gandhi Chemicals	1,500/-
16	PTFE (Teflon Solution)	200 gm Solution	Ecokem Technologies Pvt. Ltd., Mumbai	25,000/-
17	TBAOH	500gm Solution with water as base	Gandhi Chemicals	5,600/-
18	H ₂ O ₂	Hydrogen Peroxide (500ml)	Gandhi Chemicals	2,500/-
19	H ₂ SO ₄	Sulfuric Acid (500ml)	Gandhi Chemicals	1,500/-
20	Microstructure Analysis by SEM Specimen tools	SEM Images of Pt/C, Carbon Black, Nafion Membrane & Carbon Paper	CIF, SPPU, Pune	3,500/-
21	XRD Analysis & Testing specimen tools bags	20% Pt/C Catalysts	CIF, SPPU, Pune	1,500/-
22	Manufacturing of a Fuel Cell base	Laser Cutting of SS304, Acrylic, Copper & Aluminium	Kakade Laser Comp. Pvt. Ltd.	6,000/-
23	Hydrogen Cylinder	2.5kg, 5kg and 10Kg	Linde, Mumabi and Pune Air Products,	25,000/-

			Lonikal Bhor	
24	Hydrogen Sensor & Testing kit	4ppm safety and hazard detector	Industrial Detector, Indian TradeBird	20,000/-
25	Nickel Mesh, Monel Mesh or Inconel Mesh	200mesh, 150mesh, 200mesh in 1" ft running	Zain Corporation, Raviwar Peth	50,000/-
26	Miscellaneous			4,486/-
			Total	2,50,000/-

❖	Contingency			
1	Contingency			35,000/-
			Total	35,000/-

Year-wise plan of work and targets to be achieved

Duration	Jan 2024 to April 2024 (4 Months)	May 2024 to August 2024 (4 Months)	Sept 2024 to Dec. 2024 (4 Months)	Jan 2025 to April 2025 (4 Months)	May 2025 to June 2025 (2 Months)
Activity					
Literature Review w.r.t to progress of Minor Project					
Manufacturing of MEA with Micro porous Layer (MPL)					
Building the Test Setup for Single PEM FC					
Experimentation on SS304 Mesh & Nickel Mesh					
Result & Analysis of Single PEM FC					
Simulation & Computational analysis					
Writing Research Paper & Publication					
Validation of the Results with published literature					
Final Presentation to Panel along with results and publications					

Office of the

Research and Development Cell

MIT Art, Design & Technology University, Pune



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Declaration by Principal Investigator

I, **Dr. Virendra Bhojwani** declare that,

- I shall abide by the rules governing the scheme in case assistance is provided to me from the RDC for the above project.
- I shall complete the project within the mentioned period.
- I shall return the balance amount to the University account after completion of the project.
- I shall abide to hand over all the development done under this project to the University.
- The above project is not applied for funding from other external agencies.

Handwritten signature of V.K. Bhojwani in blue ink.

Signature of Principal Investigator

Handwritten signature of V.K. Bhojwani in blue ink.

Signature of HoI/Director

Seal



MIT Art, Design and Technology University

(Established by Government of Maharashtra vide Act No. XXXIX of 2015)

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Declaration by Co - Principal Investigator

I, **Mr. Mandar Patunkar** declare that,

- I shall abide by the rules governing the scheme in case assistance is provided to me from the RDC for the above project.
- I shall complete the project within the mentioned period.
- I shall return the balance amount to the University account after completion of the project.
- I shall abide to hand over all the development done under this project to the University.
- The above project is not applied for funding from other external agencies.



Signature of Co - Principal Investigator



Signature of HoI/Director



MIT Art, Design and Technology University

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International Publications of Dr. Virendra Bhojwani

- 1) Sandeep Ohol, Mathew V. K., **Virendra Bhojwani**, Naveen G Patil and Praveen Barmavatu, Effect of PCM filled Hollow Fin heat sink for Cooling of Electronic Components-A Numerical Approach for thermal management prospective, International Journal of Modern Physics -C, Vol. 1, **2024**, 229- 236
- 2) F Kharadi, **V Bhojwani**, P Dixit, NJ Kanu, N Jain, Experimental study of the operating parameters on the performance of a Single-stage Stirling cryocooler cooling infrared sensor for space application, Aircraft Engineering and Aerospace Technology, **2023**
- 3) NS Patel, S Pawar, **V Bhojwani**, Use of an earthen clay pot refrigerator with a thermoelectric cooler for extending farm produce shelf life, Frontiers in Mechanical Engineering, Vol. 09, **2023**,
- 4) Ohol S, Mathew V.K, **Bhojwani V**, Sanap S.Kakade M, Experimental study of aluminium chips to find out temperature distribution, Materials Today Proceedings, Volume 72, **2023**, 1692 – 1696.
- 5) KL Bhoite, SM Bhosle, **V K Bhojwani**, Assessment of Steering Knuckle by DFMAE Method, **2023**
- 6) Bhoyar S, Sahare S, **Bhojwani V**, Sanap S, Kulkarni, S., An Experimental Investigation of Fatigue Performance for A Flexure Spring, International Journal of Integrated Engineering, Vol 15(5), **2023**, 64–70
- 7) P Tipole, A Karthikeyan, **V Bhojwani**, S Deshmukh, H Babar, B Tipole, Examining the impact of magnetic field on fuel economy and emission reduction in IC engines, International Journal of Ambient Energy 43 (1), **2022**, 678-684.
- 8) A Jomde, **V Bhojwani**, S Deshmukh, Challenges in implementation of a moving coil linear compressor in a household refrigerator, International Journal of Ambient Energy 43 (1), **2022**, 557-560.
- 9) S Bhoyar, **V Bhojwani**, G Khutwad, G Sawant, J Lad, S Sebastian, Modal Analysis of Special Type of Flexure Bearing for Space Application, Smart Technologies for Energy, Environment and Sustainable Development, Vol 1, **2022**, 799-809.

- 10) S Phadkule, **V Bhojwani**, S Inamdar, Performance improvement in opposed Piston Linear Compressor for household refrigerator by reducing clearance volume, International Journal of Ambient Energy 43 (1), **2022**, 98-102.
- 11) FH Kharadi, A Karthikeyan, **B Virendra Bhojwani**, 40 K single-stage split-type Stirling cryocooler, International Journal of Ambient Energy 43 (1), **2022**, 216-221
- 12) SM Shinde, DM Kawadekar, PA Patil, **VK Bhojwani**, Analysis of micro and nano particle erosion by the numerical method at different pipe bends and radius of curvature, International Journal of Ambient Energy 42 (16), **2022**,1830-1837
- 13) MK Gaikwad, PA Patil, **V Bhojwani**, Numerical investigation on the performance of thermo-acoustic engine using a vertical heater, International Journal of Ambient Energy 42 (15), **2022**, 1769-1775.
- 14) SM Shinde, PA Patil, **VK Bhojwani**, Investigation of erosion phenomena and influencing factors due to the presence of solid particles in the flow: a review, International Journal of Ambient Energy 42 (11), **2022**, 1326-1334.
- 15) N Patel, O Mindhe, M Lonkar, D Naikare, S Pawar, **VK Bhojwani**, S Pawar, Performance Investigation of Mitticool Refrigerator, Techno-Societal **2020**, 1051-1061
- 16) S Vidhate, **V Bhojwani**, O Mobale, SCADA System Applied to Two-Wheeler Chassis Dynamometer, Techno-Societal **2020**, 115-127.
- 17) FH Kharadi, A Karthikeyan, **B Virendra Bhojwani**, Optimization of material of flexure spring by finite element analysis, Materials Today: Proceedings 44, **2020**, 3929-3932.
- 18) S Bhojar, **V Bhojwani**, G Khutwad, G Sawant, J Lad, S Sebastian, Finite Element Analysis to Predict Performance of Flexure Bearing for Space Application, Techno-Societal **2020**, 365-374
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- 20) DS Mane, K Arunagiri, **V Bhojwani**, Effect of mixture velocity for given equivalence ratio on flame development in Swiss roll combustor, Thermal Science 25 (1 Part A), **2020**, 85-93

- 21) A Majgaonkar, A Karthikeyan, V Sishtla, **V Bhojwani**, Review of oil separation technologies used in refrigeration systems, AIP Conference Proceedings 2311 (1), **2020**, 090003.
- 22) V Ramanathan, B Kanimozhi, **VK Bhojwani**, An experimental study of impact of inclined hollow plate containing honey-bee wax as an absorber surface in a solar still, Int. J. Tech. Res. Sci. Special, **2020**, 51-54.
- 23) SM Shinde, PA Patil, **VK Bhojwani**, An experimental study to investigate the dynamic behaviour of thermal conductivity for different concentrations of Al₂O₃ nanofluid, International Journal of Ambient Energy 41 (12), **2020**, 1321-1326.
- 24) R Venkatachalam, K Balakrishnan, **V Bhojwani**, An Experimental Study of Impact of Inclined Hollow Plate Containing Honey-Bee Wax as an Absorber Surface in a Solar Still, EasyChair
- 25) SB Sanap, **VK Bhojwani**, VK Mathew, Statement of Peer review, **2020**.
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- 27) M Shinde, R Navthar, S Shinde, **V Bhojwani**, Performance analysis of single slope solar still with improved design, International Journal of Ambient Energy, **2020**, 1-5.
- 28) A Patil, M Dhavalikar, S Dingare, **V Bhojwani**, Design and prototyping of dual axis solar tracking system for performance enhancement of solar photo-voltaic power plant, E3S Web of Conferences 170, **2020**, 01011.
- 29) P Patunkar, S Dingare, **V Bhojwani**, A Review of Recent Experimental and Theoretical Research of Dew Point Evaporative Coolers, E3S Web of Conferences 170, **2020**, 01021.
- 30) A Bawane, S Lakade, **V Bhojwani**, A Study on Performance Enhancement of Parabolic Trough Collector, E3S Web of Conferences 170, **2020**, 01030
- 31) FH Kharadi, A Karthikeyan, B Virendra, A Inamdar, Investigate the effect of regenerator mesh on cooling performance, International Journal of Ambient Energy, **2019**, 1-6.
- 32) RK Sidheshware, S Ganesan, **V Bhojwani**, Experimental investigation on the viscosity and specific volume of gasoline fuel under the magnetisation process, International Journal of Ambient Energy, **2019**,1-6.

- 33) SM Shinde, DM Kawadekar, PA Patil, **VK Bhojwani**, Analysis of micro and nano particle erosion by analytical, numerical and experimental methods: A review, Journal of Mechanical Science and Technology 33 (5), **2019**, 2319-2329.
- 34) S Phadkule, S Inamdar, A Inamdar, A Jomde, **V Bhojwani**, Resonance analysis of opposed piston linear compressor for refrigerator application, International Journal of Ambient Energy 40 (7), **2019**, 775-782.
- 35) RK Sidheshware, S Ganesan, **V Bhojwani**, An overview of viscosity reduction techniques on hydrocarbon fluids, International Journal of Ambient Energy, **2019**, 1-10.
- 36) SB Mane Deshmukh, A Krishnamoorthy, **VK Bhojwani**, Experimental investigations of effect of depth of Swiss roll combustor on its thermal performance as a heat generator, International Journal of Ambient Energy 40 (7), **2019**, 704-715.
- 37) SM Shinde, PA Patil, **VK Bhojwani**, Damage Of Nanoparticles And Pipe Surface Due To The Interaction Of A Nanofluid With System Components– An Experimental Study, Heat Transfer Research, 50 (17), **2019**.
- 38) SBM Deshmukh, A Krishnamoorthy, **VK Bhojwani**, Experimental Investigations Of Flame Patterns Observed For Lpg/Air Premixture Used In Small-Scale Swiss Roll Combustor, Heat Transfer Research 50 (11), **2019**.
- 39) FH Kharadi, A Karthikeyan, B Virendra, A Inamdar, Investigate the effect of regenerator mesh on cooling performance, International Journal of Ambient Energy, **2019**, 1-6.
- 40) S Madiwale, A Karthikeyan, **V Bhojwani**, Properties investigation and performance analysis of a diesel engine fuelled with Jatropha, Soybean, Palm and Cottonseed biodiesel using Ethanol as an additive, Materials Today: Proceedings 5 (1), **2018**, 657-664.
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- 51) A Jomde, A Anderson, **V Bhojwani**, M Deshmukh, Performance predictions and parametric analysis of a valved linear compressor using a mathematical model, *International Journal of Ambient Energy* 39 (5), **2018**, 456-461.
- 52) P Tipole, A Karthikeyan, **V Bhojwani**, S Deshmukh, B Tipole, K Shinde, Performance analysis of vapour compression water chiller with magnetic flux at the condenser exit *Energy and Buildings* 158, **2018**, 282-289.
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