



Notice for the PhD Viva Voce Examination

Ms Geethu Varghese, Registration Number: 1840085, PhD Scholar at the Department of Mathematics, School of Sciences, CHRIST (Deemed to be University), Bangalore will defend her PhD thesis at the public viva-voce examination on Thursday, 16 October 2025 at 2.00 pm in Room No. 044, Ground Floor, R & D Block, CHRIST (Deemed to be University), Bengaluru - 560029, Karnataka, India.

Title of the Thesis : **Numerical Study of Performance Optimization and Thermal Management in Polymer Electrolyte Membrane Fuel Cells**

Discipline : **Mathematics**

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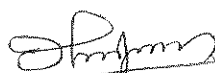
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The members of the Research Advisory Committee of the Scholar, the faculty members of the Department and the School, interested experts and research scholars of all the branches of research are cordially invited to attend this open viva – voce examination.

Place: Bengaluru
Date: 06 October 2025


Registrar (Academics)

ABSTRACT

This thesis investigates the key factors affecting thermal management, structural integrity, and performance optimization in polymer electrolyte membrane fuel cells (PEMFCs), through numerical simulations. The research explores the start-up process of high temperature-PEMFCs (HT-PEMFCs), particularly examining transient thermal gradients and stresses during start-up and cell operation, using coolant/gas channel heating with a fluid-structure interaction (FSI) approach. It is found that, while the use of polyalkylene glycol-based heat transfer fluid improves start-up time, significant temperature gradients create inhomogeneous stresses that threaten the membrane's structural integrity, especially for polybenzimidazole (PBI) membranes, which face compressive stresses exceeding their ultimate strength. A detailed heat analysis confirms that electrochemical reactions provide sufficient heat to raise the cell's temperature from 120 °C to its specified operating range quickly. The study also explores the effect of the channel to rib width (CRW) ratio and clamping pressure on HT-PEMFC performance. The results reveal that the von-Mises stress and deformation of GDLs beneath the ribs increases as the CRW ratio increases. The findings also show that the CRW ratio significantly affects performance at high current densities. For low-temperature PEMFCs (LT-PEMFCs), the thesis investigates the cold start behavior, focusing on the role of clamping pressure in managing GDL deformation and ice accumulation. It finds that uncompressed GDLs exhibit a superficial cold start performance when compared to compressed GDLs, while increased clamping pressure causes ice buildup, hindering the electrochemical reactions. Lastly, the thesis performs a sensitivity analysis on key catalyst layer parameters—platinum (Pt) loading, catalyst layer thickness, and Pt particle diameter. It concludes that Pt loading significantly impacts cell voltage and overpotential, while Pt particle diameter affects the homogeneity of overpotential. At higher current densities, the influence of some of these parameters diminishes, highlighting the importance of optimizing catalyst layer design. Overall, the research provides comprehensive insights into the factors that influence PEMFC performance, offering strategies to enhance their efficiency, reliability, and practicality for real-world applications.

Keywords: *Fuel cell, HT-PEMFC performance, PEMFC performance, Start-up, Thermal stress, Cold start, GDL deformation, Clamping pressure, CRW ratio, Sensitivity analysis, Structural parameters.*

Publications:

1. **Geethu Varghese**, Venkatesh Babu KP, Thadathil Varghese Joseph and Purushothama Chippar, "A Numerical Investigation on Thermal Gradients and Stresses in High Temperature-PEM Fuel Cell During Start-Up", *International Journal of Heat and Mass Transfer*, vol. 175, 2021, Doi: <https://doi.org/10.1016/j.ijheatmasstransfer.2021.121365>.
2. **Geethu Varghese**, Venkatesh Babu KP, Thadathil Varghese Joseph and Purushothama Chippar, "Combined Effect of Channel to Rib Width Ratio and Gas Diffusion Layer Deformation on High Temperature-Polymer Electrolyte Membrane Fuel Cell Performance", *International Journal of Hydrogen Energy*, vol. 47, no. 77, pp. 33014-33026, 2022, Doi: <https://doi.org/10.1016/j.ijhydene.2022.07.178>.
3. **Geethu Varghese**, Venkatesh Babu KP, Thadathil Varghese Joseph and Purushothama Chippar, "Impacts of Pore Scale Gas Diffusion Layer Deformation on PEMFC Performance at Sub Zero Operation", *Journal of Electrochemical Society*, vol. 170, no. 11, 2023 Doi: <https://iopscience.iop.org/article/10.1149/1945-7111/ad08ee>.
4. **Geethu Varghese**, Venkatesh Babu KP, Thadathil Varghese Joseph and Purushothama Chippar, "Effect of Coupled Microstructural Characteristics of Catalyst Layer on High Temperature: Proton Exchange Membrane Fuel Cell Performance", *Journal of Electrochemical Society*, vol. 171, no. 10, 2024 Doi: <https://iopscience.iop.org/article/10.1149/1945-7111/ad86ee>.