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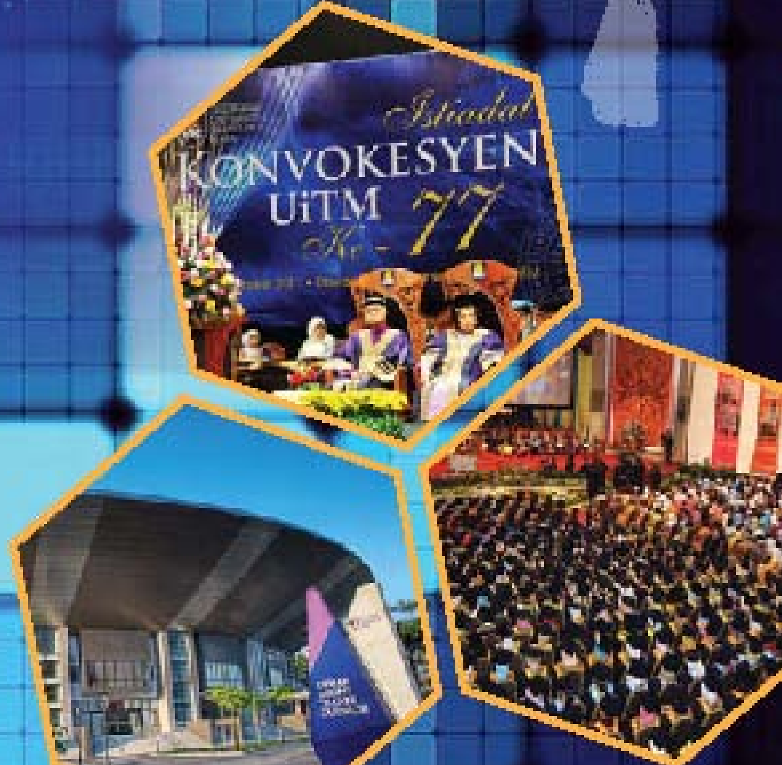

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Name : Wan Ahmad Najmi Bin Wan Mohamed

Title : **Solid-State Thermal Analysis of Air-Cooled Polymer Electrolyte Membrane Fuel Cells with Predictive Empirical Profiling**

Faculty : Mechanical Engineering

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The operation of Polymer Electrolyte Membrane (PEM) fuel cells are thermally sensitive, requiring an effective thermal engineering to cope with the generated heat. Air cooling for closed cathode PEM fuel cells is limited to stacks under 1.5 kWe. Due to great demand for fuel cells of 3 kWe or less with minimal system sizing, an effortwas taken to academically investigate the effect and behavior of various cooling channel designs, relative to PEM fuel cell operation, as a method for complementing the commercial needs. A scaled-down development approach was identified where three stacks, three cells each, with different cooling channel designs were fabricated for thermal characterization. The main objective was to develop a mathematical procedure in converting the empirical data at low electrical loadings to predict the thermal behavior of the stacks at expanded size and load. This procedure acknowledges the unique operational signatures of individual stacks which are neglected in theoretical performance formulations. Through CFD, 14 cooling channel designs were analyzed and three designs were eventually selected; one of the designs was a chaotic flow cooling channel. Incorporating the cooling channels onto a commercial bipolar plate design with a large active area (230 cm2 per cell), the stacks were tested under different electrical loads and with four cooling fan settings, a fresh approach unreported in open literature in this field of study. Physical interpretations of the electrical and temperature profiles include the polarization curve, stack efficiency, generated powers, temperature increase ratio, averaged temperature gradient and identification of active areas within the cells. Subsequent solid-state heat transfer analysis focusing on the energy changes of the stack was performed and the cooling effectiveness as well as potential of each cooling mode and design was identified. The ensuing predictive thermal modeling of the stacks at elevated powers was based on linear extrapolation method of the available cooling trends. The outcome was a detail stack temperature profile for each design and cooling setting when it is subjected to loads up to 3 kWe, within a set of assumed operating conditions. In the area of thermal engineering, this work provided different perspectives on the internal thermally related characteristics of PEM fuel cells, minus the complexity of parametric convective analysis, compared to the standard approach in available literature. The predictive modeling tool based on individual stack behavior is also regarded as a valuable analytical approach in practical cost-effective PEM fuel cell stack development.