UNIVERSITI TEKNOLOGI MARA

THERMAL MANAGEMENT IMPROVEMENT OF A LIQUID COOLED PROTON EXCHANGE MEMBRANE FUEL CELL THROUGH ADOPTION OF Al_2O_3 NANOFLUIDS AS COOLING MEDIUM

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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 27th April 2016 to conduct the final examination of Irnie Azlin @ Nur Aqilah Zakaria on her Doctor of Philosophy thesis entitled "Thermal Management Improvement of a Liquid Cooled Proton Exchange Membrane Fuel Cell Through Adoption of Al_2O_3 Nanofluids as Cooling Medium" in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The panel of Examiners was as follows:

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Proton Electrolyte Membrane Fuel Cell (PEMFC) has started to gain global attention nowadays due to the greener aspect of this technology with almost 90 % emission reduction as compared to internal combustion engine. However, in order to improve the thermal performance efficiency of a PEM fuel cell, an excellent thermal management system acquisition is strongly required. This study hybridized nanofluids and PEM fuel cell technologies into cooling medium of PEM fuel cell in order to improve the thermal management. To author's knowledge, experimental study of nanofluids in an electrically active heat transfer device such as PEM fuel cell is almost none. The study focuses on Alumina oxides (Al_2O_3) nanofluids characterization, understanding heat transfer and fluid flow behaviour of Al_2O_3 nanofluids in a single cooling plate and later on establishing thermo electrical and thermo fluid performance of a full-scale PEM fuel cell with the adoption of Al_2O_3 nanofluids as the cooling medium. In this study, Al_2O_3 nanofluids with volume concentration of 0.1, 0.3 and 0.5 volume % have been dispersed in base fluids of water and two mixtures of water and ethylene glycol (EG), which are 60:40 and 50:50 (W:EG). Critical thermo-physical properties of nanofluids mainly electrical conductivity, viscosity and thermal conductivity were measured. Prandtl number and Thermo-electrical conductivity (TEC) ratio were established. These properties were applied to both numerical and experimental study in order to understand the behaviour of Al_2O_3 nanofluids in term of heat transfer enhancement and pressure drop penalty in a single cooling plate of PEM fuel cell. Advantage ratio (AR) was calculated which measure the feasibility of the adoption from heat transfer enhancement to pressure drop penalty aspect. Finally, thermo electrical and thermo fluid effect of Al_2O_3 nanofluids in a full-scale liquid cooled PEM fuel cell was established. The result shows that the highest cooling rate improvement was 187 % with 0.5 volume % concentration of Al_2O_3 nanofluids in 100:0 (W:EG). This was followed with 147 % enhancement in 0.3 volume % concentration of Al_2O_3 nanofluids in 100:0 (W:EG). However, there was a drop in electrical power produced, which is 31 and 15 % respectively as compared to water-cooled PEM fuel cell. Thermo electrical (TE) ratio calculated shows that 0.1 volume % of Al_2O_3 nanofluids in 100:0 (W:EG) are the most feasible Al_2O_3 nanofluids for PEM fuel cell adoption. Thermo fluids analysis through AR was found in a good agreement with TE ratio findings. It was concluded that despite of the high electrical conductivity characteristic of Al_2O_3 nanofluids, the thermal management improvement was still achievable as compared to conventional coolant. It is recommended that further study conducted with different nanoparticles and base fluids to extend the understanding of the nanofluids adoption in an electrically active heat transfer device such as fuel cell.

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