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THERMAL PROPERTIES OF WATER-ETHYLENE GLYCOL BASED HYBRID AL_2O_3-SIO_2 NANOFLUIDS IN PEMFC COOLING PLATE

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ABSTRACT

Proton Electrolyte Membrane fuel cell (PEMFC) is seen as one of the viable alternative energies to internal combustion engine (ICE) due to the clean product bypass. However, the performance of PEMFC needs to be optimized through excellent thermal management. The main duty of thermal management system is to maintain the desirable temperature with a uniform temperature distribution across the stack and individual membranes. The passive heat transfer method was considered by altering the thermophysical property of the coolant of PEMFC which is water:EG base fluid. In this study, hybrid Al_2O_3:SiO_2 nanofluids with base fluid of water:EG were analysed in terms of critical thermophysical properties for PEMFC application, which are thermal conductivity, dynamic viscosity and electrical conductivity. The hybrid nanofluids with low concentration of 0.5% volume was used due to the limitation of electrical conductivity limit for PEMFC. This is essential as it helps to avoid electrical leakage to the coolant which will decrease the power generation and also to reduce the possibility of shunt current. The study focused on four hybrid ratios of Al_2O_3:SiO_2 nanofluids of 10:90, 30:70, 50:50 and 70:30 in water:EG mixture. It was observed that up to 8.64% of improvement was shown in the hybrid Al_2O_3:SiO_2 nanofluids for thermal conductivity as compared to base fluid. However, the improvement was also accompanied by viscosity and electrical conductivity increment in hybrid Al_2O_3:SiO_2 nanofluids as compared to base fluid. The thermal enhancement of PEMFC cooling plates was also analysed and presented. The hybrid Al_2O_3:SiO_2 nanofluids was used as coolant in the PEMFC cooling plates. A 3D computational fluid dynamic (CFD) Ansys Fluent version 16.0 was used to simulate the serpentine and distributor cooling plates of PEMFC. The study focused on comparative analysis of water:EG mixture, single Al_2O_3 and single SiO_2 nanofluids, and hybrid Al_2O_3:SiO_2 nanofluids in terms of heat transfer enhancement and pressure drop in Reynold number (Re) ranging from 300 to 1800. A positive heat transfer enhancement was observed where the hybrid 10:90 (Al_2O_3:SiO_2) nanofluids had the highest heat transfer coefficient in both cooling plates as compared to other candidates. However, all nanofluids experienced higher pressure drop. Therefore, the advantage ratio was used to analyse the effect of both heat transfer enhancement and pressure drop demerit for nanofluids adoption. The results concluded that 10:90 (Al_2O_3:SiO_2) hybrid nanofluid is the most feasible candidate as compared to others. Meanwhile, the performance in distributor cooling plate was seen better than the serpentine cooling plate.

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