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Exploring thermal hydraulics characteristics of hybrid TiO_2-Cu/Water nanofluid in a triangular array of PWR subchannel using ANSYS Fluent

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The application of advanced fluids with improved thermal properties is a potential approach to enhance heat transfer efficiency in nuclear reactors, resulting in an elevation in the safety margin. This study investigates the impact of a hybrid TiO_2-Cu/water nanofluid on the thermodynamic behavior of coolant flow within a triangular array of a PWR subchannel. A single-phase flow of a homogeneous mixture of species was assumed. The analysis considers Reynolds numbers ranging from 20,000 to 80,000, in increments of 20,000, and evaluates three nanoparticle volume ratios: 1% TiO_2–3% Cu, 2% TiO_2–2% Cu, and 3% TiO_2–1% Cu. Key performance parameters analyzed include variations in the Nusselt number, convective heat transfer coefficient, temperature distribution, enthalpy gain, shear stress, and pressure drop. This study exhibited that the addition of nanoparticles enhances the overall convective heat transfer coefficient by an average of 5.2% compared to the base fluid (water). A higher volume fraction of TiO_2 improves heat transfer performance, although the rate of improvement relative to the water decreases as the Reynolds number increases. Among all the combinations, the 3% TiO_2–1% Cu ratio demonstrates the most efficient heat transfer based on temperature profile and Nusselt number trends. However, it also incurs a notable pressure drop. In contrast, the 1% TiO_2–3% Cu combination yields a reduction of 4.31% on average in pressure drop compared to the water. The flow dynamics and heat dissipation characteristics of the hybrid nanofluid were thoroughly examined using CFD simulations in ANSYS Fluent.

Technical Track

Nuclear Thermal-Hydraulics

Primary author: HAQUE, Amrin Nahar (University of Dhaka)

Co-authors: ROY, Sabyasachi (University of Dhaka); ISLAM, Md. Shafiqul (University of Dhaka)

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