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CFD Simulations on a hexagonal 61-pin wire-wrapped fuel bundle with STARCCM+ and comparison with experimental data.

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In this work, several CFD simulations of the hexagonal 61-pin fuel bundle replica of the Thermohydraulic Research Lab at Texas A&M University were performed. This fuel assembly geometry is a helically wire wrapped bundle of rod pitch-to-diameter ratio of 1.89 and helix pitch-to-diameter ratio of 29.93, as in Sodium-cooled fast breeder reactors (FBR). The experimental activity has produced a large set of data that is compared against simulations. The purpose of the present study is to optimize computational fluid dynamics and compare the code predictions of pressure drops (friction factors) against experimental data and available correlations. The friction factor is of paramount importance in determining reactor features like pump specification and safety limits.

The commercial software STARCCM+ Version 14.04.013 was chosen to perform the simulations. Four different turbulence models were utilized to compare with the experimental data: k-epsilon (standard and realizable) and k-omega (standard and SST). The code predictions were also compared with the upgraded Chen and Todreas detailed correlation (UCDT).

For the geometry under study, the laminar to transition (RebL) and transition to turbulent (RebT) Reynolds numbers are RebL=494 and RebT=13,554. The experimental data was generated within Reynolds ranging from 439 to 13,766. Therefore, the simulations were focused in the transition regime, although there were simulations run at laminar Reynolds numbers.

The Incompressible Reynolds-Averaged Navier-Stokes Equation (RANS) with an eddy viscosity turbulence model was used in the calculations. Two meshes were utilized. The first mesh was used to perform simulations with these turbulence models; however, a second mesh was created with the intention of enhancing the results of k-ω SST.

Within the laminar regime, no turbulence model was needed. The simulation results exhibited a good comparison with the experimental data with an error of 2.81 % and the UCTD, with and error of 7.60%.

At the transition regime, the k-omega standard model with the first mesh produced the best prediction of the experiment (all simulation values were within the uncertainty interval) and the UCTD, while the two k-epsilon models overpredicted the friction factor. Regarding the k-omega SST model, results obtained with the first mesh were more distant to the experiment than the standard model. A better prediction was obtained using the second mesh, because this mesh had an average Y+ less than 1, which was not the case of the first mesh. Using Y+<1 is a requirement for the SST to accurately predict pressure and velocity mean field.

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