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A Computational Fluid Dynamics Simulation of Single Rod Bundles with 54 Fuel Rods without Spacers

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Abstract : The Advanced Heavy Water Reactor (AHWR) is a vertical pressure tube type, heavy water moderated and boiling light water cooled natural circulation based reactor. The fuel bundle of AHWR contains 54 fuel rods arranged in three concentric rings of 12, 18 and 24 fuel rods. This fuel bundle is divided into a number of imaginary interacting flow passage called subchannels. Single phase flow condition exists in reactor rod bundle during startup condition and up to certain length of rod bundle when it is operating at full power. Prediction of the thermal margin of the reactor during startup condition has necessitated the determination of the turbulent mixing rate of coolant amongst these subchannels. Thus, it is vital to evaluate turbulent mixing between subchannels of AHWR rod bundle. With the remarkable progress in the computer processing power, the computational fluid dynamics (CFD) methodology can be useful for investigating the thermal–hydraulic characteristics phenomena in the nuclear fuel assembly. The present report covers the results of simulation of pressure drop, velocity variation and turbulence intensity on single rod bundle with 54 rods in circular arrays. In this investigation, 54-rod assemblies are simulated with ANSYS Fluent 15 using steady simulations with an ANSYS Workbench meshing. The simulations have been carried out with water for Reynolds number 9861.83. The rod bundle has a mean flow area of 4853.0584 mm2 in the bare region with the hydraulic diameter of 8.105 mm. In present investigation, a benchmark k-ε model has been used as a turbulence model and the symmetry condition is set as boundary conditions. Simulation are carried out to determine the turbulent mixing rate in the simulated subchannels of the reactor. The size of rod and the pitch in the test has been same as that of actual rod bundle in the prototype. Water has been used as the working fluid and the turbulent mixing tests have been carried out at atmospheric condition without heat addition. The mean velocity in the subchannel has been varied from 0-1.2 m/s. The flow conditions are found to be closer to the actual reactor condition.

Keywords : AHWR, CFD, single-phase turbulent mixing rate, thermal–hydraulic
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