World Academy of Science, Engineering and Technology
International Journal of Nuclear and Quantum Engineering
Vol:10, No:04, 2016

Thermal Hydraulic Analysis of Sub-Channels of Pressurized Water Reactors with Hexagonal Array: A Numerical Approach

Authors : Md. Asif Ullah, M. A. R. Sarkar

Abstract : This paper illustrates 2-D and 3-D simulations of sub-channels of a Pressurized Water Reactor (PWR) having hexagonal array of fuel rods. At a steady state, the temperature of outer surface of the cladding of fuel rod is kept about 1200°C. The temperature of this isothermal surface is taken as boundary condition for simulation. Water with temperature of 290°C is given as a coolant inlet to the primary water circuit which is pressurized upto 157 bar. Turbulent flow of pressurized water is used for heat removal. In 2-D model, temperature, velocity, pressure and Nusselt number distributions are simulated in a vertical sectional plane through the sub-channels of a hexagonal fuel rod assembly. Temperature, Nusselt number and Y-component of convective heat flux along a line in this plane near the end of fuel rods are plotted for different Reynold's number. A comparison between X-component and Y-component of convective heat flux in this vertical plane is analyzed. Hexagonal fuel rod assembly has three types of sub-channels according to geometrical shape whose boundary conditions are different too. In 3-D model, temperature, velocity, pressure, Nusselt number, total heat flux magnitude distributions for all the three sub-channels are studied for a suitable Reynold's number. A horizontal sectional plane is taken from each of the three sub-channels to study temperature, velocity, pressure, Nusselt number and convective heat flux distribution in it. Greater values of temperature, Nusselt number and Y-component of convective heat flux are found for greater Reynold's number. X-component of convective heat flux is found to be non-zero near the bottom of fuel rod and zero near the end of fuel rod. This indicates that the convective heat transfer occurs totally along the direction of flow near the outlet. As, length to radius ratio of sub-channels is very high, simulation for a short length of the sub-channels are done for graphical interface advantage. For the simulations, Turbulent Flow (K-Є) module and Heat Transfer in Fluids (ht) module of COMSOL MULTIPHYSICS 5.0 are used.

Keywords : sub-channels, Reynold's number, Nusselt number, convective heat transfer
Conference Title : ICNPPE 2016 : International Conference on Nuclear Power Plants Engineering
Conference Location : Boston, United States
Conference Dates : April 25-26, 2016