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CFD investigation of thermal-hydraulic characteristics in a SFR fuel assembly

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The wire effect on three-dimensional flow field and heat transfer characteristics in a helically wrapped fuel assembly mock-up of an SFR (Sodium-cooled Fast Reactor) have been investigated through a numerical analysis using the commercial CFD (Computational Fluid Dynamics) code, CFX. The SFR system has a tight package of the fuel bundle and a high power density. The sodium material has a high thermal conductivity and boiling temperature than the water. That can make core design to be more compact than LWR (Light Water Reactor). The fuel assembly of the SFR system consists of long and thin wire-wrapped fuel bundles and a hexagonal duct, in which wire-wrapped fuel bundles in the hexagonal duct has triangular array. The main purpose of a wire spacer is to avoid collisions between adjacent rods. Furthermore, a vortex induced vibration can be mitigated by wire spacers. The wire spacer can enhances a convective heat transfer due to the secondary flow by helically wrapped wires.

In this study, complicated and separated flow phenomena in the fuel assembly without wire spacer and with wire spacer were captured by a RANS (Reynolds-Averaged Navier-Stokes) flow simulation with the SST (Shear Stress Transport) turbulence model, and by the vortex structure identification technique based on the critical point theory.

It is concluded that the wire spacers locally induce a tangential flow by up to about 13 % of the axial velocity. The tangential flow in the corner and edge sub-channels is much stronger than that in the interior sub-channels. The flow with a high tangential velocity is periodically rotating in a period of wire lead pitch. The cross flow due to the wire spacer can achieve to enhance heat transfer characteristics up to about 50 %.

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