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Computational fluid dynamics study for estimation of dilution for failed fuel location system

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In a pool type sodium cooled fast reactor, in case of detection of failure of a fuel subassembly (FSA) by global delayed neutron detection system, localization of failed subassembly would be done using the Failed Fuel Location Module (FFLM). This is achieved by sampling sodium at exit of each subassembly and looking for presence of delayed neutrons. For a 500 MWe prototype design, as part of this system there are sampling tubes for each FSA placed as annular tubes concentric to thermo-wells of core temperature monitoring system. Each sampling sleeve admits sodium sample from a specific subassembly, through an annular channel within a sampling sleeve.The sampling end at the bottom of sampling sleeve is at axial separation of about 130 mm from respective subassembly outlet.
The aim of thepresent study is to estimate dilution in concentration of a delayed neutron precursor suffered during sampling of (contaminated) sodium for FFLM system. This is necessitated due to the complex hydraulics with multiple interacting jets at varied temperatures and flow rates emanating from numerous SA outlets. Due to the configuration of reactor assembly, outlet jets from SA top attain a significant radial component at the cost of their axial components. The prevailing velocity and temperature fields lead to complex hydraulics within hot pool of a fast reactor. The presence of diverse scales (large domain with large number of small structures) makes this study highly challenging. Towards this, a detailed three dimensional CFD model of a 90^{o} sector of hot pool of reactor has been developed with inner vessel, control plug and connected structures, intermediate heat exchanger and pump standpipes. Core outlet has been modeled accurately with individual outlets for fuel and blanket subassemblies. All other subassemblies have been grouped together appropriately. Each discrete FFLM sampling sleeves are modeled along with shrouds for control rods. Such detailed modeling approach allows estimation of dilution for flow from individual subassemblies. The complete paper would summarize the dilution estimates from numerous runs for each monitored subassembly. It is seen from the studies that species dilution is insignificant for all fuel subassemblies with the maximum dilution predicted being 0.02 %. This ensures reliable and accurate sample collection for failed fuel localization.

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