Proceedings of the 7th World Congress on Mechanical, Chemical, and Material Engineering (MCM'21)
~~Prague, Czech Republic~~ Virtual Conference – August, 2021
Paper No. HTFF 127 (The number assigned by the OpenConf System)
DOI: 10.11159/htff21.127

Examination of Complicated Thermal Hydraulic Characteristics in Core Region of a PWR

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Extended Abstract

Reactor coolant enters at cold-leg nozzles, goes down along the down-comer, changes flow direction and goes up passing through core region, and then exits hot-leg nozzles under normal operation of typical PWRs (Pressurized Water Reactors). Since temperature variance caused by inertia resistance and decay heat as well as pressure drop due to fuel assemblies are important and complicated in the core region, lots of efforts have been devoted to relevant design and evaluation.

Even if narrow down to CFD analyses, however, it is not easy to simulate large and complex shapes of the fuel assemblies and their features as they are. To resolve this issue, a number of researchers have been adopted alternative porous media. For instance, Cheng et al. [1] investigated thermal hydraulic characteristics subjected to asymmetric conditions. Kutuk et al. [2] examined flow mixing characteristics for full-loop and three-loop cases. Kansal et al. [3] analysed temperature distributions in vertical calandria vessel with spatial and uniform distribution of volumetric heat generation.

The objectives of this study are to address thermal hydraulic characteristics in the core region and to quantify their dependency. Reactor vessel with internals were considered and an optimized CFD model was developed for a 600MWe reactor. Parametric analyses were carried out by assigning temperatures of 286℃ at inlet and 320℃ at outlet with a pressure of 15.5 MPa. Not only uniform heat generation rate was applied as a source but also porosity, permeability and pressure drop coefficient were set to fuel assemblies bulk model.

Resulting pressure and temperature distributions were compared. In particular, effects of pressure drop, heat generation and their interaction were discussed. Effectiveness of porous media and influence of different flow paths to reflect design change were also examined. Moreover, application of the CFD analysis results to thermal and structural analyses for subsequent studies will be introduced.

References

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