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Progress in system thermohydraulic code HYDRA-IBRAE/LM models development for fast reactor simulation

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The system thermohydraulic code HYDRA-IBRAE/LM is designed for the simulation of non-stationary thermohydraulic processes in liquid metal and water circuits of fast reactors under normal operating conditions, anticipated operational occurrences and accidents. The code uses a two-fluid model in all flow regimes except for dispersed annular flow, where a three-fluid model is applied. Besides advanced mathematical models, the code has advanced pre- and postprocessor and utility for performing multivariative calculations, uses MPI and OpenMP parallelization. The code is being developed in "Codes of New Generation"subproject of "Proryv" project.
New models described in the present paper expand the code applicability and reduce the degree of conservatism in the nuclear power plants safety assessment.
One direction of the code development is the improvement of dispersed phase transport model. The new model accounts for the flow parameters time dependence and allows performing correct calculation of the bubble diameter necessary for the description of heat transfer and interfacial friction. The interfacial area density equation describes its dynamics and determines bubble diameter in one-group approximation. A more sophisticated heterogeneous multi-group model allows describing bubble dynamics and processes of separation and stratification.
The improved post dryout model was implemented for water coolant. Post dryout flow is treated as steam-water annular two-phase flow. In considered conditions deposition of droplets from the flow core on the hot tube wall takes place. The new model describes post dryout heat transfer in the pressure range 3-16 MPa with high accuracy.
The turbine model was developed and implemented in the code. The model describes the thermal-hydraulic processes taking place as the energy of superheated steam transforming into mechanical work. The model is based on the universal thermodynamical relations and self-consistently calculates enthalpy and pressure drops at the turbine stages. This approach allows determination of the thermal-hydraulic parameters of the coolant (temperature, density, pressure, enthalpy, entropy, mass fraction of water) in all elements of the turbine for a given load.
The work was performed on enabling the description of water behavior at supercritical parameters which is extremely important for correct modeling of the experiments where supercritical water was used.
Performed validation calculations made it possible to refine correlations used in the closure relations.

Country/Int. organization

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