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Experimental and computational studies of heat exchange for liquid metals boiling in fuel assembly models at accidental conditions

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The higher level of modeling for dynamic liquid metal boiling is important for comprehensive analysis of neutron-physical and thermohydraulic characteristics of fast reactors cores for safety justification at accidental conditions (UTOP, ULOF).
Experimental data obtained at IPPE JSC have showed that boiling of liquid metals in fuel assemblies of fast reactors has a complex structure which is characterized by both stable and pulsation regimes with significant fluctuations of parameters that can cause a boiling crisis.
Stable nucleate boiling in fuel assembly models is observed only at limited heat fluxes; and transition to unstable bubble-slug boiling regimes is determined by various factors. In an assembly with a low surface roughness of pin simulators, progressing of unstable (slug) boiling with sharp fluctuations of the coolant flow rate and overheating of the pin simulator wall causes the boiling crisis; in fact, there is no any margin before the crisis. For the pin simulators with higher roughness a transition from unstable slug boiling regimes to stable annular-dispersed boiling regimes is observed due to a liquid film on the surface of the pin simulators.
The hydrodynamic interaction of fuel assemblies can result in to considerable increase in the amplitude of fluctuations in the flow rate of the coolant ("resonance" of the flow rate pulsations) and to the "locking" or inversion of the flow rate of the coolant in the loops, increase in the temperature of the coolant and the pin claddings (the effect of interchannel instability) and, finally, to the boiling crisis.
During sodium boiling in a model fuel assembly with a "sodium cavity" located at the top of the reactor core (the cavity is designed to compensate the positive sodium void reactivity effect when boiling occurs) the possibility of prolonged sodium cooling of the pins in the fuel assemblies for these conditions is shown.
The generalization of data on heat transfer at liquid metals boiling in fuel assemblies is carried out; a cartogram of the flow regimes for two-phase flow of liquid metals in fuel assemblies is developed. The model of the two-phase flow of liquid metal used in the calculations of accidental conditions has been improved; it has a significant impact on the calculation results. The results of comparing the data of calculated and experimental studies are presented.

Country/Int. organization

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