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Modeling of hydrodynamic processes at a large leak of water into sodium in the fast reactor coolant circuit

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A description is given of a physico-mathematical model of the processes that occur in the sodium circuit with a variable flow cross-section in case of a water leak into sodium. The application area for this technique includes a possibility to analyze consequences of this leak as applied to sodium-water steam generators in fast neutron reactors.
Hydrodynamic processes that occur in the sodium circuit in the event of a water leak are described within the framework of a 1-D thermally-nonequilibrium three-component gas-liquid flow model (sodium-hydrogen-sodium hydroxide). In this case hydrogen is assumed to be an ideal gas and its solubility in sodium is taken into account. Consideration is also given to dependence of sodium and sodium hydroxide on pressure and temperature.
In the proposed improved approach the sodium circuit is presented in the form of combination of two models:
• a 1-D model with distributed parameters, that describes dynamics of the parameters in all the circuit elements (sodium-water reaction region included), with the exception of expansion tank volume;
• an expansion tank model built as part of the model with lumped parameters.
These two models are cross-linked in the expansion tank inlet and outlet points.
The proposed model and calculation technique have been realized in the form of a computer code.
A computer code was tested on experimental data obtained from the injection of water vapor into sodium at the Russian sodium loop.
Results gained from a comparison of calculations with experimental data, lead us to conclude that the proposed technique adequately reflects the transient behavior of the relevant parameters during the hydrodynamic processes that occur in sodium-water interaction in a sodium circuit.

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