Rod bundle thermalhydraulics mixing phenomena: 3D analysis with cathare 3 of ROSA-2/LSTFexperiment

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ROD BUNDLE THERMALHYDRAULICS MIXING PHENOMENA: 3D ANALYSIS WITH CATHARE 3 OF ROSA-2/LSTF EXPERIMENT

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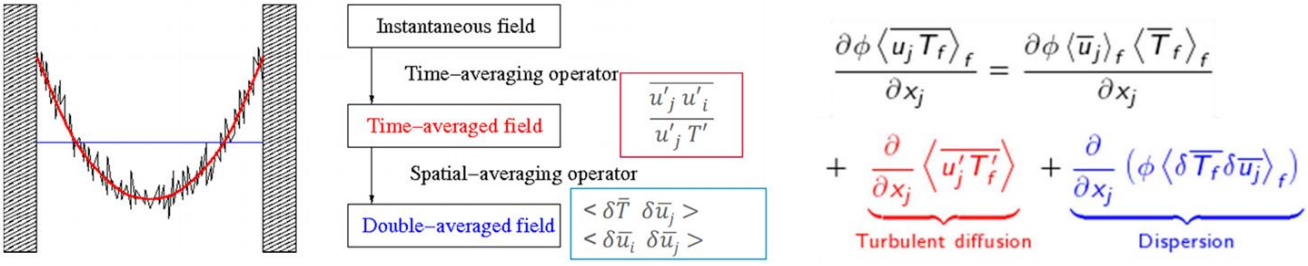
ABSTRACT

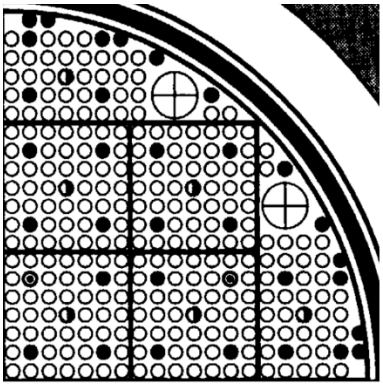
CATHARE-3 is the new version of the French thermal-hydraulic code for the safety analysis of nuclear reactors [1]. There is a three-dimensional (3-D) module in CATHARE-3 mainly used to model the reactor vessel (specially the core). This 3-D module is based on the "porous" medium approach with two-fluid six equations model. Therefore, one set of mass, momentum and energy balance equations is written for each phase. These equations are established using a double-averaged method: first, a time-average to filter the pseudo-random variations of the flow variables due to turbulence and two-phase intermittence, and then, space-average to account for the interactions of the flow with the internal solid structures. This is illustrated by the figure and the equation bellow.

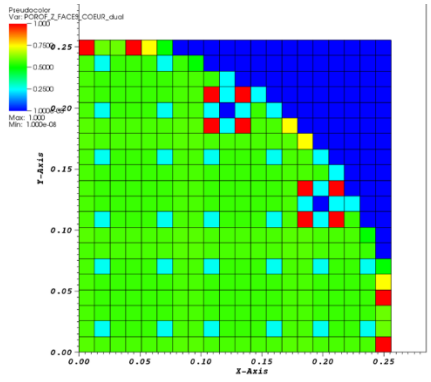


Optional terms can be added in momentum and energy balance equations to model turbulent diffusion and dispersion effects. These terms have an impact on core simulation at subchannel scale. So, the CATHARE team had established models for these terms in rod bundle geometry and had validated them on various rod bundle experiments [2].

The presented simulations are a quarter modeling (thanks to the symmetry of the geometry and of the experimental conditions) of the core of the ROSA-2/LSTF experiment using the CATHARE-3 3-D module with a radial nodalization of one mesh per rod. On the figures bellow, one can see, left, a scheme of the experimental core, and right, the radial nodalization used in CATHARE-3 calculations with the porosity field. A phase of core uncovering during which the rod temperatures in the dry zone increase is observed in an experimental test [3]. Experimental conditions at the bottom and at the top of the core have been reproduced in the calculation. Experimental evolutions of the rod temperatures are compared with CATHARE-3 calculations with and without the turbulent diffusion and the dispersion terms.

This modeling also shows the capabilities of CATHARE-3 to manage a large number of 3D-cells (about 15 000 useful) and to perform simulations comparable to the simulation of a whole PWR assembly at the subchannel scale.





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