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Investigating the thermalhydraulics of nuclear fuel bundles and functional spacers using cold-neutron tomography at the ICON beamline

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Neutron imaging of industrial two-phase flows, being a promising technique, has gained increasing attention in the last two decades. We focus on annular flows in nuclear fuel bundles. For annular flows, occurring typically at the upper part of the fuel bundles of boiling water reactors (BWRs), the potential dryout of the coolant liquid film constitutes a safety concern and is a limiting factor in the thermal power and thus for the economy of the reactor. We investigate adiabatic, air-water annular flows in a scaled-up model of two neighboring subchannels as found in BWR fuel assemblies using cold-neutron tomography. The imaging of the double subchannel has been performed at the ICON beam line at the neutron spallation source SINQ at the Paul Scherrer Institute, Switzerland. Cold-neutron tomography is proven here to be an excellent tool for investigating annular flows and the influence of functional spacers on such flows. Different fuel bundle geometries and as well spacer geometries have been investigated in a series of experiments. The high-resolution, high-contrast measurements provide the spatial distributions of the coolant liquid film thickness on the fuel pin surfaces as well as on the surfaces of the spacers, including the vanes. Monte Carlo simulations of the imaging have also been performed to be able to optimize the measurement accuracy and to avoid biasing effects.

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