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EFFECT OF BURN-UP AND FUEL ELEMENT FLUX TILT ON CHF IN PHWR BUNDLES IN UNCREPT AND CREPT FLOW TUBES

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Abstract. In multi-scale / multi-physics modelling of Pressurized Heavy Water Reactors (PHWRs), the neutron flux and fission power profiles through a fuel bundle and along a fuel element are important aspects in the reactor physics part of the simulations. The power profiles change with fuel burn-up. In addition, the skin effect from Pu build-up has been observed at the surface layer of fuel elements as the burn-up progresses. As a result, the element power distribution has a sharp increase near the fuel surfaces due to inhomogeneous distribution of Pu (mostly due to 239Pu in PHWRs). Modern reactor physics (RP) lattice codes (such as WIMS-AECL 3.1) are capable of predicting the details of power distribution at the length scales of ~ 0.1mm (or less) from basic principles. On the other hand, thermalhydraulics (TH) subchannel codes (such as ASSERT-PV) use models to describe inhomogeneous power distribution along the fuel pins (e.g., a flux tilt model). In this work, we demonstrate how one can combine WIMS-AECL 3.1 with ASSERT-PV for a multi-physics simulation of PHWR fuel bundles with asymmetric power distribution within fuel elements inside pressure tubes. Although the effects of changes in element power distributions with burn-up on critical heat flux (CHF) and dryout power are expected to be small, they need to be accurately quantified for the outer ring elements where the power peak at the surface due to the Pu skin effect and the power gradient within a fuel element are expected to be high.

We also discuss RP and TH modelling of the pressure tube (PT) creep effect in PHWRs using detailed models of fuel bundles in WIMS-AECL 3.1 and ASSERT-PV. PT creep results in a larger gap at the top of a bundle in a horizontal channel, so one needs to quantify its impact on the power distribution through the bundle and within fuel pins due to the asymmetry between the top and the bottom of a bundle. As an example, the effect of burn-up and pressure tube creep on the distribution of power within fuel elements, and hence on the CHF and dryout power, will be investigated for a 43-element fuel bundle.