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IMPLEMENTATION OF USER MATERIAL LAWS (UMAT) FOR CLEARANCE ANALYSIS IN IRRADIATED COOLING CHANNELS OF CNAI

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Abstract.

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This work investigates deformations and clearances in the internal coolant channels of the Atucha I Nuclear Power Plant (CNA I) reactor. Using three-dimensional simulations in Code-Aster, we implemented user material subroutines (UMATs) to model the in-service behavior of austenitic stainless steel and Zircaloy-4. The constitutive laws include irradiation-induced phenomena—radiation growth, time-dependent creep, and volumetric swelling—that alter material properties and mechanical response. Realistic boundary conditions and external loads were applied, including spatial temperature and pressure fields. Channel-level simulation results were combined with pre-existing displacements of the reactor pressure vessel (RPV) closure head to compute the resulting clearances. The study lays the groundwork for more reliable analysis and assessment of reactor internals—essential for safety and life-extension at CNA I—by integrating the coupled effects of irradiation into user-defined material models that capture the interplay between dimensional stability and mechanical integrity in operation.

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