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Reactivity Assessment of Enhanced Accident Tolerant Claddings in a Modern PWR

As part of an ongoing DOE NEUP project intended to develop a process to evaluate the whole-core operational and safety performance of fuel/clad combinations that promise to enhance accident tolerance, this work investigated the reactivity performance of several Accident Tolerant Fuels (ATFs) used in a contemporary PWR. The reactor used was the Watts Bar Nuclear Unit 1 Cycle 1 (WBN1C1). The ATFs under study evaluated five types of accident tolerant claddings, namely, 304 stainless steel, 310 stainless steel, iron-chromium-aluminum (FeCrAl), APMT™, and silicon carbide (SiC). Using the 3-D nodal simulator NESTLE with cross sections produced by CASMO-4, the End of Cycle (EOC) k_{eff} for each cladding concept was matched by adjusting two design parameters; ^{235}U enrichment and fuel pellet radius, the latter which can be increased to compensate for thinner claddings. Accordingly, this work determined the enrichments required for three different fuel radii (or cladding thicknesses), none of which required the enrichment to exceed 5% ^{235}U. However, varying pellet radius without increasing enrichment, while keeping gap thickness and outer clad diameter constant, was not sufficient to match the EOC reactivity of the zirconium alloy base case for neither the two steels nor the two ferritic alloys. Conversely, SiC, as expected, exceeded the reactivity performance of Zircaloy throughout the cycle length. These results show consistent trends with previous studies carried out on the basis of lattice physics calculations on PWR bundles (i.e., without a full-core analysis) and are consistent with recent full-core studies performed on a BWR.