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3-D Core Design of the TRU-Incinerating Thorium RBWR Using Accident Tolerant Cladding

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This project investigates the safety of the optimal core design for the RBWR-TR –a reduced moderation BWR with a high transuranic (TRU) consumption rate. This design is a variant of the Hitachi RBWR-TB2, which arranges its fuel in a hexagonal lattice, axially segregated seed and blanket regions, and fits within a standard ABWR pressure vessel. The RBWR-TR eliminates the internal axial blanket and absorbers from the upper reflector, and uses thorium instead of depleted uranium for the axial blankets. Its coolant flow rate is higher than of the TB2 design. Both designs are initially presented with Zircaloy-2 cladding.
The softer neutron spectrum of the RBWR-TR core, along with its lower peak linear heat generation rate, results in a lower cladding fast neutron fluence than of the RBWR-TB2 core. However, the peak fluence of fast neutrons (E >= 0.1 MeV) the cladding is exposed to exceeds the limits for Zircaloy-2, making this material not acceptable even for the RBWR-TR design. At such high fast fluence levels, zirconium-based cladding experiences faster rates of corrosion and hydrogen pickup, which embrittles the cladding and eliminates any margin for accident scenarios. Alternative cladding materials to Zr-based alloys are being investigated for accident tolerant fuels such as stainless steel based materials that are not limited by hydrogen pickup phenomena. However, the steel cladding penalizes the neutron economy and limits the discharge burnup. The design variables of the parametric studies include the cladding material type, cladding thickness, gap between fuel and cladding, fuel smear density and fuel-to-moderator volume ratio. The changes of the void feedback, cycle length, burnup, shutdown margin, and critical power ratio to variation in each of the design variables are calculated to determine the optimal design. A design that meets all the design constraints will be presented.

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