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2-D Fuel Meat Temperature Assessment of SELENIUM Plates

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ABSTRACT

Irradiation-induced interdiffusion between U-Mo particles and Al matrix is one of the phenomena suspected to limit overall fuel performance. A thin coating layer (ZrN or Si) was applied on U-Mo particle surface as a diffusion barrier in the SCK·CEN SELENIUM test. Destructive examinations of the irradiated plates show that significant amount of UMo-Al interdiffusion layer (IL) formed in high burnup region (> 4 - 4.5×10^{21} fissions/cm^3-UMo), but the IL is negligible at low burnup. Hypotheses have been put forward to explain the IL formation behavior of coated particles. One possible explanation is that substantial IL growth occurs only in regions where temperature and fission rate are above a threshold value, resembling what was observed in chemical ion mixing experiments. In order to verify the hypothesis, it is important to reasonably estimate fuel temperature distributions in the fuel plates during irradiation. Since it is impossible to measure fuel temperature during irradiation, DART-2D, a 2-dimensional (2-D) FORTRAN framework, was developed to estimate the fuel meat temperature distribution in a full-size plate. The calculation scheme evaluates time-dependent fuel temperatures throughout a plate in both longitudinal and lateral directions, using provided power histories and fuel plate fabrication parameters as inputs. Thermal conductivity degradation caused by IL formation in fuel meat and gas bubble formation inside fuel particles is updated at each time step. Besides fuel temperature distribution, location-wise output information includes plate thickness increase, fuel particle swelling, and constituent volume fractions as a function of fission density. The calculated microstructural information at the end of the SELENIUM test is found to be in good agreement with the experimental measurement.

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