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Preliminary Safety Performance Assessment of ESFR CONF-2 Sphere-pac-Fueled Core

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Within the European FP-7 project PELGRIMM, oxide fuel forms for Minor Actinide (MA) transmutation were researched for both homogeneous and heterogeneous recycling in Sodium-cooled Fast Reactors (SFRs).

Among the investigated fuels, sphere-pac fuels were given priority emphasis, as they offer great advantages compared to pellet fuels when MAs are to be embedded, while presenting, however, one major drawback, the latter being their low thermal conductivity.

In order to determine the actual suitability of sphere-pac fuels for use in SFRs, safety analyses were planned within the PELGRIMM Work Package 4, so as to provide a first assessment of both the transient behavior of sphere-pac-loaded cores as compared to the reference ones incorporating classical pellet MOX fuel, and the relative safety margins.

In a broader perspective, such a study was expected to help identify potential hindrances preventing the use of MOX sphere-pac fuels, as well as needs for further code development and validation.

A preliminary safety assessment of the CONF-2 version of the European Sodium Fast Reactor core (ESFR) at Beginning of Life, loaded with both pellet and sphere-pac fuels was performed by using the BELLA code and the SAS4A/SASSYS-1 code, with core neutronic characteristics and safety parameters being calculated with the Serpent code.

Both the reference Unprotected Loss Of Flow (ULOF) and an Unprotected Transient Over-Power (UTOP) accidents were simulated, along with a set of sensitivity studies.

As major outcomes of this study, it could be preliminarily concluded that the use of sphere-pac fuel may bring some disadvantages from the safety point of view in the event of a UTOP accident, whereas no concerns are raised for a ULOF scenario.

In particular, the dynamic response of the ESFR CONF-2 core loaded with sphere-pac fuel to a ULOF accident resulted to be essentially not affected by the characteristics and properties of this innovative fuel; conversely, in the event of a UTOP, safety margins would be reduced, due its low thermal conductivity, leading to larger magnitudes of the fuel temperature gradients ensuing from positive reactivity insertions.

Consistently with the previous conclusions, uncertainties in the determination of the fuel thermal conductivity and Doppler constant were found to have no significant impact on the ULOF transient predictions, but to influence the UTOP simulations, making their accurate determination critical for the system safety assessment.

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