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Elaboration of Ceramic Metal Accident Tolerant Fuels by Additive Manufacturing

Authors : O. Fiquet, P. Lemarignier

Abstract : Additive manufacturing may find numerous applications in the nuclear industry, for the same reason as for other industries, to enlarge design possibilities and performances and develop fabrication methods as a flexible route for future innovation. Additive Manufacturing applications in the design of structural metallic components for reactors are already developed at a high Technology Readiness Level (TRL). In the case of a Pressured Water Reactor using uranium oxide fuel pellets, which are ceramics, the transposition of already optimized Additive Manufacturing (AM) processes to UO_2 remains a challenge, and the progress remains slow because, to our best knowledge, only a few laboratories have the capability of developing processes applicable to UO_2. After the Fukushima accident, numerous research fields emerged with the study of ATF (Accident tolerant Fuel) fuel concepts, which aimed to improve fuel behaviour. One item concerns the increase of the pellet thermal performance by, for example, the addition of high thermal conductivity material into fissile UO_2. This additive phase may be metallic, and the end product will constitute a CERMET composite. Innovative designs of an internal metallic framework are proposed based on predictive calculations. However, because the well-known reference pellet manufacturing methods impose many limitations, manufacturing such a composite remains an arduous task. Therefore, the AM process appears as a means of broadening the design possibilities of CERMET manufacturing. If the external form remains a standard cylindrical fuel pellet, the internal metallic design remains to be optimized based on process capabilities. This project also considers the limitation to a maximum of 10% volume of metal, which is a constraint neutron physics considerations impose. The AM technique chosen for this development is robocasting because of its simplicity and low-cost equipment. It remains, however, a challenge to adapt a ceramic 3D printing process for the fabrication of UO_2 fuel. The investigation starts with surrogate material, and the optimization of slurry feedstock is based on alumina. The paper will present the first printing of Al2O3-Mo CERMET and the expected transition from ceramic-based alumina to UO_2 CERMET.

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