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Development of Innovative Nuclear Fuel Pellets Using Additive Manufacturing

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Abstract : In line with the strong desire of nuclear energy players to have ever more effective products in terms of safety, research programs on E-ATF (Enhanced-Accident Tolerant Fuels) that are more resilient, particularly to the loss of coolant, have been launched in all countries with nuclear power plants. Among the multitude of solutions being developed internationally, carcinoembryonic antigen (CEA) and its partners are investigating a promising solution, which is the realization of CERMET (CERamic-METal) type fuel pellets made of a matrix of fissile material, uranium dioxide UO2, which has a low thermal conductivity, and a metallic phase with a high thermal conductivity to improve heat evacuation. Work has focused on the development by powder metallurgy of micro-structured CERMETs, characterized by networks of metallic phase embedded in the UO_2 matrix. Other types of macro-structured CERMETs, based on concepts proposed by thermal simulation studies, have been developed with a metallic phase with a specific geometry to optimize heat evacuation. This solution could not be developed using traditional processes, so additive manufacturing, which revolutionizes traditional design principles, is used to produce these innovative prototype concepts. At CEA Cadarache, work is first carried out on a non-radioactive surrogate material, alumina, in order to acquire skills and to develop the equipment, in particular the robocasting machine, an additive manufacturing technique selected for its simplicity and the possibility of optimizing the paste formulations. A manufacturing chain was set up, with the pastes production, the 3D printing of pellets, and the associated thermal post-treatment. The work leading to the first elaborations of macro-structured alumina/molybdenum CERMETs will be presented. This work was carried out with the support of Framatome and EdF.

Keywords : additive manufacturing, alumina, CERMET, molybdenum, nuclear safety
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