FLASH SINTERING, A NOVEL TECHNIQUE, FOR MANUFACTURING SURROGATE AND ACTIVE NUCLEAR MATERIALS

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This project, conducted through a collaboration between National Nuclear Laboratory (NNL), Lucideon, University of Manchester and Orano, demonstrated a novel flash sintering technology to fabricate dense uranium dioxide (UO_2) pellets, of a size that would be consistent with the requirements of the Nuclear Decommissioning Authority's (NDA) disposal Mixed Oxide (MOX) concept. In flash sintering an electric field is applied during the densification of green bodies which enables lower temperatures and shorter sintering cycles to be used, which could lead to cost savings in the disposition of the UK's separated civil plutonium.

The use of an alternating current and bespoke non-linear control software, developed by Lucideon, have been shown to be important in controlling the flash process and ensuring homogeneous and consistent microstructures. The development started using surrogate fuel Cerium Oxide (CeO_2) under the Advanced Fuel Cycle Programme (AFCP), whereby the process and flash sintering parameters where optimised to reliably produce homogeneously 96% dense 12.5mm diameter pellets. Transitioning to active materials, the process was then applied to UO_2. Theoretical densities of 94 - 96% were achieved on green bodies ranging from 6.7 to 14.1 mm diameter. The addition of a neutron poison, as may be required for disposal MOX, was also demonstrated by fabricating UO_2 pellets containing 1 wt.% gadolinia (Gd_2O_3).

A preliminary assessment was also carried out for the industrial scale-up of the technology, based on modifying existing continuous sintering furnaces currently used by Orano for the manufacture of MOX fuel pellets. This concluded that for large disposal MOX pellets, the throughput could be increased by over 70% through flash sintering technology with conservative estimates. The remaining challenges concern the need to keep pellets isolated from one another and to make electrode contacts with each pellet. The next stage in development of this technology would be to demonstrate the scale-up to a multi-pellet system to confirm the predicted throughput improvements and to demonstrate that during flash sintering plutonium dioxide readily forms a solid solution with UO_2, as is the case with conventional sintering of MOX fuel.

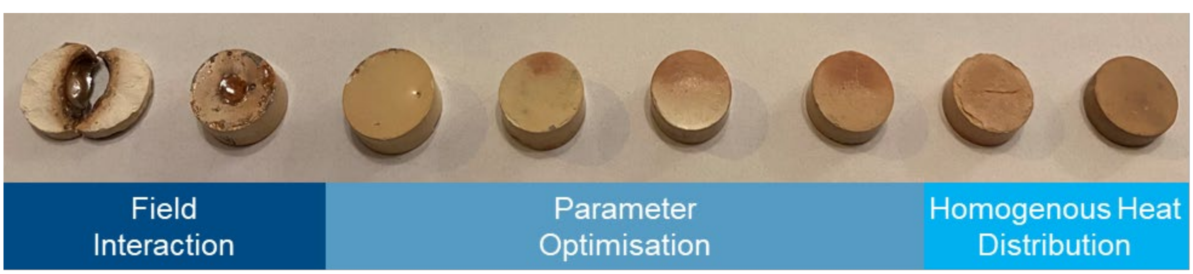

Figure 1 - The evolution of cerium oxide pellets representing the progressive optimization of flash sintering parameters.