
Radiation Effects on Zirconium Alloys Produced by Powder Bed Fusion Additive Manufacturing Processes

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ABSTRACT:

Additive Manufacturing (AM) is an enabling technology for novel designs and complex shapes that cannot be produced using traditional manufacturing methods. For nuclear fuel, novel designs of spacer grids, and top and bottom nozzles can provide better coolant mixing and heat transfer, lower pressure drop, and better debris capture. These benefits will improve fuel reliability and operating margins. Additionally, there are a significant number of potential applications for LWRs and next generation reactors.

The objective of this project is to evaluate radiation performance of zirconium materials produced using laser powder bed fusion AM. Westinghouse has developed additive manufactured zirconium alloy through its industrial partner ATI and has inserted the materials into MIT reactor for irradiation beginning in Fall 2015. As of June 2016, the samples have accumulated ~1 dpa in reactor. Visual inspection showed black oxide formed on specimen surface and there are no signs of oxide spallation or crud deposition. In order to further understand the irradiation behavior of additive manufacturing zirconium alloy, post irradiation examination (PIE) is proposed. The PIE work is proposed to be performed at the Westinghouse Churchill hotcell facility, an NSUF partner facility. The effect of processing on its material properties such as hardness, tensile strength, ductility, and irradiation induced microstructure changes as well as hydrogen pickup will be investigated. The results will be used to further optimize the additive manufacturing zirconium alloy powder and the component fabrication processing parameters.

The project is a PIE only proposal because all previous development work was self-funded including the MITR irradiation. Samples have been taken out of the MITR and are currently stored in the MITR hotcell. A total of 12 AM samples were irradiated together with 4 Zircaloy-2 base alloys. It is proposed that 4 out of the 12 AM samples be examined in 2017 and the rest of the samples be re-inserted into the MITR for continued irradiation. The irradiation position has been secured. By the end of the project, samples irradiated to three different dpas will be examined. The outcome of this project will provide critical data to support qualification of AM materials for use in reactor components.

Planned NSUF work involves:

- Westinghouse Materials Center of Excellence
 - In-hot cell mechanical testing of miniature tensile specimens and fractography
 - Materials property/performance evaluations including hardness and immersion density
 - Microstructural characterization including SEM, EDS, and EBSD
 - TEM analysis irradiation to 1, 2, and 3 dpa at prototypical PWR conditions