Irradiation Testing of Materials Produced by Additive Friction Stir Manufacturing

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ABSTRACT:
The MELD process (FKA additive friction stir, AFS) developed by Aeroprobe is an advanced solid-state method for manufacturing large components, which can be applied to building future nuclear plants. The technique is faster than other additive manufacturing techniques (like techniques base on melting and solidification); depending of the material used, it can be over an order of magnitude faster. It also generates an equiaxed microstructure with low grain size that requires little to no post-processing for grain refinement and to achieve excellent mechanical properties.

This project will demonstrate that MELD produced materials can be used to produce critical SMR and advanced reactor components, while reducing the cost and schedule of construction for new nuclear power plants. It will also allow the use of advanced materials (like new ODS alloys) for large complex parts where their use was not possible due to the difficulty of joining those materials.

The purpose of this work is to perform irradiation and post-irradiation examination of materials produced by MELD manufacturing and analogous advanced manufacturing technologies, potentially including laser powder bed additive manufacturing, hot isostatic pressing (HIP) bonding and diffusion bonding. MELD is an innovative, disruptive, and potentially transformative solid-state thermomechanical process that was recently pioneered and demonstrated by Aeroprobe. It holds enormous potential for efficient near-net shape fabrication and joining of many alloys. This truly additive solid-state thermomechanical process can be used for manufacturing (of similar or dissimilar metals), repair, and coating. Significant work performed by Aeroprobe demonstrated that this technique permits the manufacturing of materials with equivalent or improved properties compared with wrought materials. Compared with other additive manufacturing technique, MELD is much faster, generates a refined equiaxed structure, and does not require the post-manufacturing treatments needed for processes based on melting and solidification, like selective laser melting (SLM) and direct metal deposition (DMD).

To use this technique for fabrication of Light Water Reactors (LWR), Small Modular Reactors (SMR) and advanced reactor internal components, it is necessary to evaluate the effect of irradiation on the material properties, which is the goal of this project.