Microstructural and fracture surface analysis of TIG-welded Zircaloy-4

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Zircaloy-4 enjoys extensive use in the nuclear industry due to its' excellent radiation stability, mechanical properties, corrosion resistance, and for its' limited hydrogen uptake. The primary application of the material, however, has been as fuel cladding at operating temperatures of 300°C. Potential future applications of Zircaloy-4 involve welded parts and may be required to operate below this temperature range. Therefore, understanding the low temperature behavior of welded Zircaloy-4 and potential post weld heat treatments is vital to these applications. Previous work in pursuit of maximizing the ductility after welding investigated heat treatments of single-hour temperature holds, at 100°C increments between 500-800°C, on tungsten inert gas (TIG) welded Zircaloy-4. The resulting welds showed variable quality. For example, welded Zircaloy-4 heat treated for one hour at 800°C had a range of 6.7% to 19.7% total elongation, a difference of nearly 300%. Microstructural evolution of the weld and heat affected zone, including the development of β-Zr structures from the welding and/or heat-treatment processes are of concern. This work focuses on understanding the previously observed variations in tensile elongation through fracture surface analysis, microstructure near the fracture, and microhardness testing. Future work will investigate the effects of low temperature neutron irradiation on the welded Zircaloy-4.

This research work was supported by the US Department of Energy's National Nuclear Security Administration, Office of Material Management and Minimization, Molybdenum-99 Program. This manuscript has been authored by UT-Battelle, LLC, under Contract No. DE-AC05-00OR22725 with the US Department of Energy.