Residual Stresses in a Welded Zircaloy Cold Neutron Source Containment Vessel

P. Bendeich[1], V. Luzin[2], M. Law[1]

[1]Institute of Materials Engineering, ANSTO, Locked Bag 2001, Kirrawee DC, Australia
[2]Bragg Institute, ANSTO, Locked Bag 2001, Kirrawee DC, Australia

Zirconium alloys are widely used in the nuclear industry because of their relative high strength, neutron transparency, resistance to high neutron-irradiation environment and corrosion resistance. One application for Zirconium alloy Zr-2.5Nb is the vacuum confinement vessel utilised in the cold neutron source of the OPAL research reactor at ANSTO. Having a total length of more the 3 meters, it contains sections joined using electron beam welding. The weld and the nearby regions are critical for the performance and integrity of the component and therefore understanding of the residual stresses development within the weld is important in connection to (i) evolution of fine dual phase α/b microstructure and crystallographic texture (ii) and stress-related radiation induced phenomena, such as grain growth, creep and sub-critical crack growth by delayed hydride cracking. The stresses were measured in and around an electron beam weld produced during the trial development of this component of the OPAL Cold Neutron Source. To reduce the effects of a large grain size in the weld, the sample was rotated to increase the swept volume. Due to the heat-treatment after welding, the stresses were very low, less than 10% of the yield strength of the material, in both the hoop and axial directions. As a result of phase transformation effects during the welding process the final stresses are compressive in the weld, which reduces the likelihood of fracture or of hydride formation in this region. The highest stresses are in the parent material adjacent to the weld where the toughness is expected to be higher than in the weld material.

Corresponding Author: philip.bendeich@ansto.gov.au; michael.law@ansto.gov.au