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Neutron Diffraction Investigation of Residual Stresses in Nickel Based Austenitic Weldments on Creep Resistant Cr-Mo-V Material

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Abstract. Residual creep ductility of service-aged Cr-Mo-V creep resistant material is considerably lower than that of new material; this affects the long-term creep life performance of components manufactured from such alloys as the creep rate in aged alloy is considerably higher than for new materials. This study focused on the effects of residual stress and post-weld heat treatment (PWHT) on the remaining life of creep-exhausted material after repair welding using nickel-based consumables. Residual stresses attributed to the ferrite-to-austenite phase transformations involve a sudden volume change of the weld material. This can adversely affect aged material, e.g. a $\frac{1}{2}\text{Cr}-\frac{1}{2}\text{Mo}-\frac{1}{4}\text{V}$ alloy, with low creep ductility and known notch sensitivity rendering this alloy prone to reheat cracking. Coupons prepared from creep damaged Cr-Mo-V pipes (323 mm outside diameter and 36 mm thick) were joined with the tungsten inert gas (TIG) and manual metal arc (MMA) welding processes simulating the original construction joints. Standard welding procedures were used with and without the addition of stress relief and temper post-weld heat treatment. Butt weld coupons were subsequently prepared, using a Ni-based consumable and a conventional ferritic consumable, for tri-axial stress measurements on the SALSA neutron diffraction beamline (ILL Grenoble), d_0 calibration used toothcomb specimens sectioned from the weld coupons. The industrial application of the experiments was sensitivity analysis of residual life prediction in FE modelling of plant system stresses in weld-repaired Cr-Mo-V creep resistant materials.

Introduction

The welding of high temperature and pressure components on power plants is considered a well-established and mature technology. It is used extensively during construction and maintenance activities. Maintenance activities, however, include welding and the effects of thermal aging of materials and components due to operation under load. These thermal effects can include phenomena such as a reduction in ductility, creep damage and high notch sensitivity that could render a component irreparable.

The chromium-molybdenum-vanadium (Cr-Mo-V) family of creep resistant alloys is known to be susceptible to weld and heat treatment related problems such as reheat cracking [1], also known as stress-relief cracking (SRC). This phenomenon is typified by cracks that occur in the coarse grained heat-affected zone, designated as a Type III crack in the categories proposed by Schüller [2], according to their location and geometry in a weld. Brett [3] subsequently added the

