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VEQTER

Residual Stress Experts

VEQTER is an engineering company providing excellence in the measurement, analysis and management of residual stresses. We are world leaders in our field and offer expertise on any aspect related to residual stresses in engineering components and structures.

Case Study: Narrow Gap Dissimilar Metal Weld Pipe

Prior knowledge of the magnitude and distribution of residual stresses in welded components is essential if cost effective analyses of the integrity of the components are to be made. AREVA NP has recently developed, for EPR applications, narrow gap welding techniques for joining thick section, ferritic steel components to austenitic stainless steel piping systems in nuclear reactors.

For this project the Neutron Diffraction (ND) and Deep-Hole Drilling (DHD) measurement techniques were used to obtain the residual stresses acting along the weld centreline, and in the heat affected zones (HAZ) of the ferritic and stainless steel sides of the weld. The ND and DHD measurements were carried out independently in order to provide cross-validation and confidence in their results. The cross-validation measurements were carried out at depths up to 40mm (maximum measurement depth of the ND technique) in order to provide confidence in the lone, DHD measured results for the other pipes under investigation with wall thicknesses greater than 40mm. VEQTER's measurement mapping procedures were also employed to provide estimates of the full field residual stress distributions.

To find out how VEQTER can help you, please contact us on +44 (0) 117 992 7970 or using experts@veqter.co.uk

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Component design:

The component was a narrow gap, TIG butt-welded pipe (Fig. 1), consisting of a section of ferritic steel pipe (type 16MND5) and a section of austenitic stainless steel pipe (type 316L). The pipe had an outer diameter of 352mm, with a thickness of 40mm and a length of 500mm. At mid-length, a circumferential, narrow gap, nickel-base alloy (alloy 52) weld had been applied to join the two sections together. The ferritic steel pipe had a stainless steel (309L and 308L), cladding layer of 8mm thickness on the inner diameter surface.

Fig. 1: Photograph of the pipe

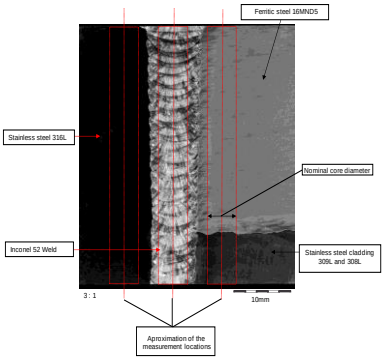

Fig. 2: Measurement locations

Measurement locations:

The measurement locations and the axes of the reference holes were such that the residual stresses in the pipe axial and hoop directions were measured together with the associated in-plane shear as functions of radial depth. The DHD measurements were carried out on the mock-up at the following locations (Fig. 2):

- Through the weld centreline
- Through the ferritic pipe and cladding HAZ region
- Through the stainless side pipe HAZ region

Results:

The DHD results were compared with ND and numerical weld modelling results, and found to be in very good agreement (Fig. 3 & 4).

Reference: Ficquet, X., et al., *"Residual Stress Measurement and Finite Element Mapping on a Narrow Gap Dissimilar Metal Weld"*, 14th Intl Conf on Environmental Degradation of Materials in Nuclear Power Systems – 203243.

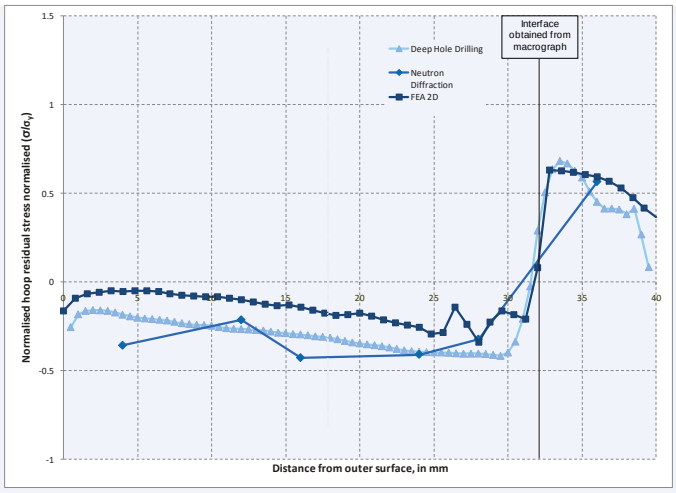

Fig. 3: Comparison of normalised hoop residual stresses measured at 9mm from the weld centreline, i.e. in the ferritic HAZ region.

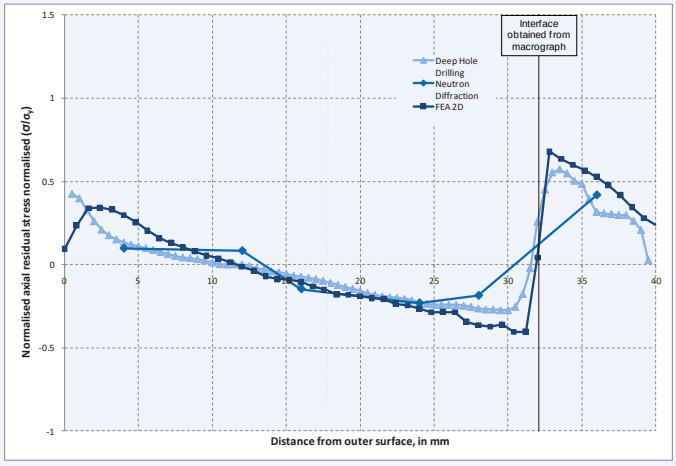

Fig. 4: Comparison of normalised axial residual stresses measured at 9mm from the weld centreline, i.e. in the ferritic HAZ region.

VEQTER Ltd's mapping procedure was then carried out to provide an estimate of the full field residual stress profiles using the limited measurement data available.

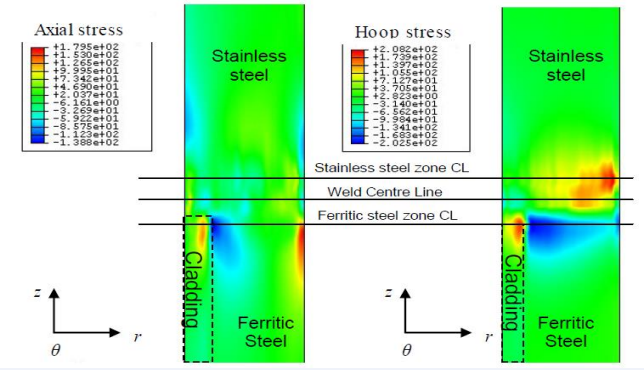

Fig. 5: Estimated residual stresses achieved from measurement mapping