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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: Effect of corrosion on the residual stresses in a girth weld pipe

The structural integrity of oil and gas pipelines are increasingly factored into the design of new installations to ensure that operating risks are kept low. In addition, the life extension of existing assets beyond their original anticipated design life, as a result of the current oil price environment and the need to optimise field development expenditure, is an ongoing challenge. Operators would like to extend pipeline service life, while many of the technologies required for the validation of their ongoing condition are not yet mature enough to provide confidence that this is a viable strategy. One of the issues considered as a key threat to pipeline integrity is corrosion. Therefore understanding the distribution and redistribution of residual stresses within a pipeline affected by corrosion can be of great benefit.

This Case Study presents the measurement of residual stresses in a pipe mock-up containing typical “corrosion” damage. Contour, iDHD, ICHD, XRD and Ultrasonic residual stress measurements were carried out to ascertain the change in stresses due to “corrosion” and validate a FEA simulation.

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Component Design:

The pipe specimen, see Fig. 1, was made from ferritic steel API 5L X52. The specimen had a length of about 410mm and an outer diameter of 762mm. It contained a seam weld along the length of the pipe and a circumferential girth weld at mid-length. A 360°, 150mm wide cut-out had been machined on the inner diameter at mid-length reducing the thickness of the pipe from 25mm to about 19mm in the weld area.

Fig. 1: Photograph of the pipe

Measurement Locations:

A total of 75 XRD measurements were carried in the ID and OD across the weld. 6 ICHDs were performed on the ID and OD, at the WCL, 20mm away from the WCL and 38mm away from the WCL. 2 iDHDs were performed at the WCL and in the HAZ in order to determine the through thickness residual stresses induced by the welding process. The Contour measurement location was an axial-radial plane through the pipe. The Ultrasonic measurements were carried out across the weld before and after machining a groove to simulate internal corrosion.

Residual stress before corrosion:

Fig. 2 shows the through thickness and Contour 2D map of the hoop residual stresses at and around the WCL location. At the OD surface the XRD results show a low compressive value which rapidly increases to high tension as shown by the ICHD results. The iDHD and Contour results show predominantly high tensile stresses throughout the thickness of the weld. The iDHD technique gave near yield stress values whilst the Contour results were lower.

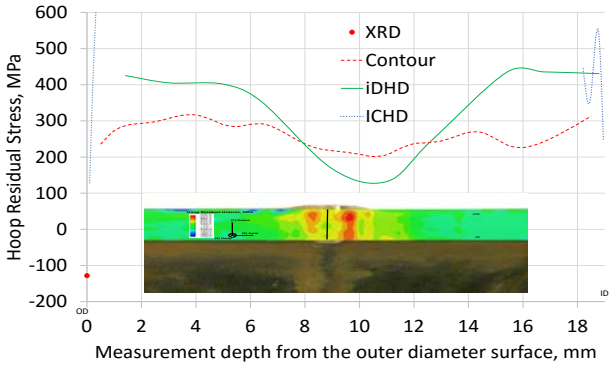

Fig. 2: Hoop residual stress comparison at the WCL

Fig. 3: Preferential weld corrosion

Corrosion simulation:

Offshore pipelines are subject to internal corrosion reducing the structural integrity of the pipe, for example, the Preferential Weld Corrosion (PWC) considered here. Typically, the deepest PWC zones cover about 30% of the circumference of the pipe.

Fig. 4: Groove machining

This study was carried out to evaluate the change in residual stresses as a groove was incrementally machined from the ID covering about 5-6% of the pipe circumference, see Fig.4. In order to validate the FE simulation, see Fig. 5, the change in the residual stress field was measured by a modified DHD technique.

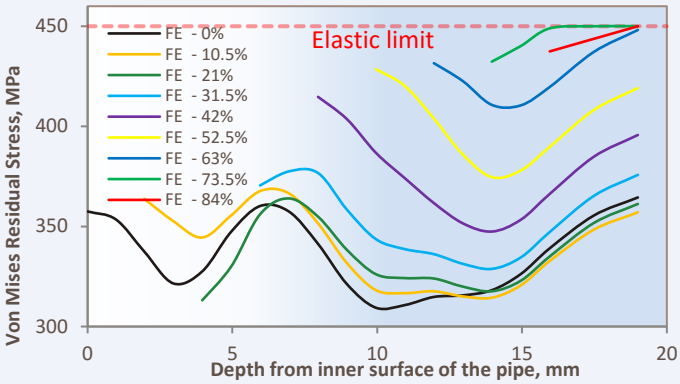

Fig. 5: FE Von Mises residual stresses in the ligament after each increment machined

Fig. 6: Ultrasonic wedge

Ultrasonic residual stress measurements were carried out across the weld near the groove location, see Fig. 6 and compared with those before the groove. The Ultrasonic measurements used the same calibration coefficients found before the groove. The after groove results show a much higher tensile peak than those taken before groove results. The Ultrasonic measurement after the groove seems to overestimate the residual stresses, see Fig. 7, however a clear difference in the residual stress levels was found using the non-destructive technique. Further work is now being carried out to improve the Ultrasonic technique for use in the field.

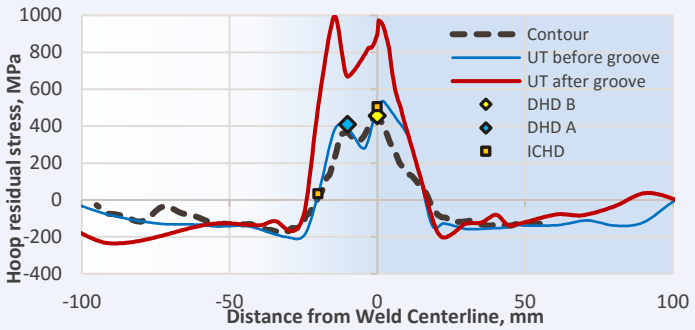

Fig. 7: Ultrasonic measurement across the weld before and after the groove

References: R. Romac ICRS2016, K. Serasli PVP2016-63880