Experimental report

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Proposal: 1-02-224 **Council:** 4/2017

Title: Fracture analysis of a crack undermechanical loading in a residual stress field

Research area: Engineering

This proposal is a new proposal

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Samples: P91 and 316LN

Instrument	Requested days	Allocated days	From	To
SALSA	9	4	12/04/2018	16/04/2018

Abstract:

Welding process is a source of very high magnitude residual stresses in the components, which affect the performance of the welded joints in service especially in fracture and crack growth. Therefore it is essential to understand how the stress-field ahead of the crack-tip varies with the application of load in the presence of residual stresses. The experiment aims at measuring the strength of the crack tip stress/strain field under in-situ fracture in the presence of residual stresses. In general, residual stresses increase the crack-tip constraint. However with the crack length increasing, some of the residual stresses are relaxed thereby modifying the crack-tip constraint and the stress-state ahead. In order to study the interaction of residual/applied stresses, it is required to determine this variation of the stress-state ahead of the crack-tip under crack extension. Further, this information is vital for validating the simulation models of defect behaviour under fracture in the presence of highly localised residual stresses in a welded component.

Fracture analysis of a crack under mechanical loading in a residual field

Aim:

Measure crack-tip strain fields under in-situ fracture in a dissimilar electron beam (EB) weld to study the interaction of residual stresses and their relaxation on the fracture propensity.

Sample:

The specimen is a C(T) specimen extracted from a dissimilar metal EB weld made between stainless steel (316LN) and ferritic/martensitic steel (P91). The crack is introduced in the centre of the weld using fatigue pre-cracking. The measurements of the specimen are 40mm x 38mm with a nominal thickness of 10 mm.

Experimental Set-up:

The measurements were made as a stress grid around the crack-tip at mid-thickness of the specimen under mode I fracture on the stress-rig. The strain measurements were made for 4 loading steps at every 1 mm of increment in the load-line displacement measured. The images of the loading set-up and the strain measurement on SALSA is shown in Fig. 1. The measurement point grid on the specimen is indicated in Fig. 2.

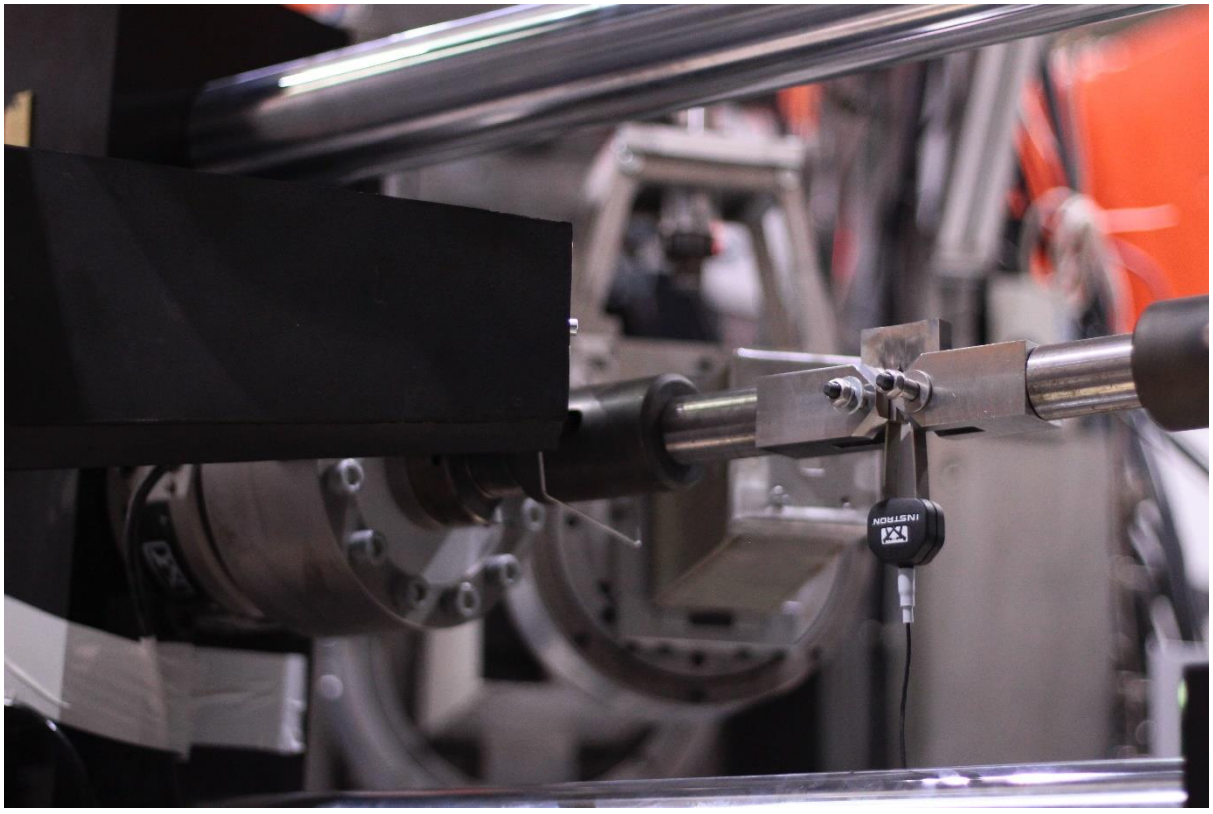

Fig. 1 In-situ measurement set-up on the C(T) specimen under loading

The instrument gauge volume used was 0.6mm x 0.6mm x 2mm. The grid spacing was 0.5mm and therefore, there is an overlap between two consecutive measurement lines. The measurements on the P91 (ferritic) side and the austenitic side were made on the <211> and <311> peaks respectively.

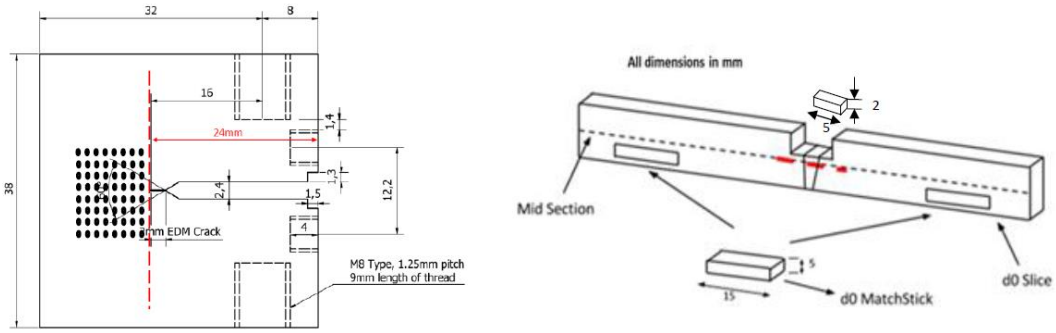

Fig. 2 Measurement grid on C(T) specimen (left) and d0 specimen with measurement lines (right)

Results:

Based on the measurements, the strains are evaluated using a Young's modulus and Poisson's ratio of 210 GPa and 0.3 for P91 and 194 GPa and 0.27 for austenite respectively. The strain contours around the crack-tip evaluated at 0 mm and 4 mm of LLD are displayed in Fig. 3 and Fig. 4 respectively.

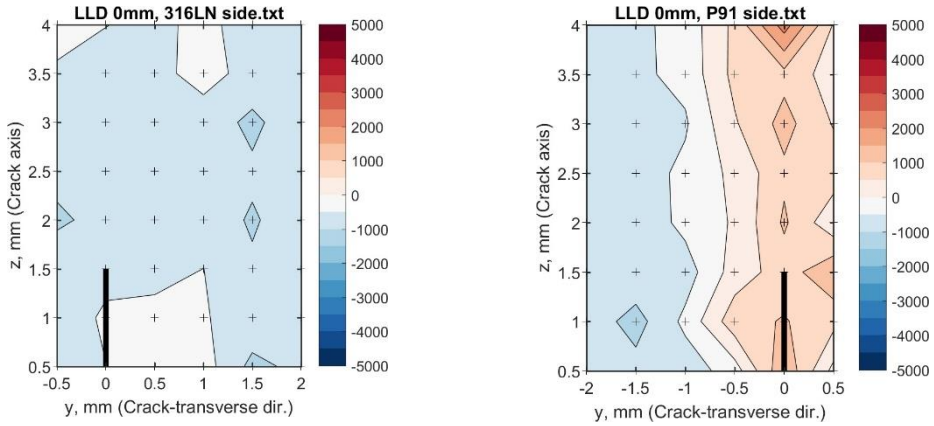

Fig. 3 Measured crack-tip strain on 316 LN (left) and P91 (right) before loading

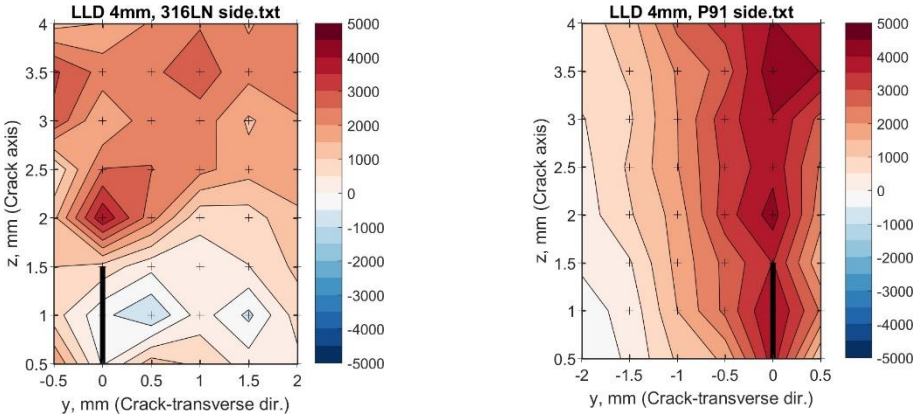

Fig. 4 Measured crack-tip strain on 316 LN (left) and P91 (right) at 4 mm of LLD

It can be seen that the residual stress field is primarily compressive in Fig. 3 arising from the welding process. Upon application of load, the strain slowly turns tensile due to the applied load. Furthermore, this information will be utilised for validating the predicted strain field of an FE model of the C(T) specimen with weld residual stresses under fracture.