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INVESTIGATING BULGE CORRECTION IN THE CONTOUR METHOD FOR RESIDUAL STRESS MEASUREMENT OF A COMPACT TENSION WELD SPECIMEN

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ABSTRACT

In this study the published iterative finite element (FE) bulge error correction procedure (Prime, 2011) was applied to a compact tension (CT) weld specimen that appeared to show bulge error in the measured residual stress results made by the contour method. The corrected contour stresses demonstrated that the bulge error could have significant effects on reliable measurements made using the contour method.

Keywords: residual stress, finite element method, contour method, bulge error.

INTRODUCTION

Like other mechanical strain relief techniques the contour method assumes that the relaxation of residual stress during the material removal step is purely elastic. However, there is an assumption unique to the contour method; that is producing a cut with a uniform width. In practice a deviation from this cutting requirement, referred to as the bulge error or elastic bulging (Prime, 2011), violates the assumption that a constant amount of material is removed during cutting. As cutting proceeds, the stresses in the material continually change and cause the material at the cut tip to deform i.e. stretch or contract. The cutting wire diameter is fixed, which means that the width of material removed has changed. Bulge errors tend to show a shift in stress distribution towards the origin of the cut along with reduced peak stresses.

To correct for the bulge error Prime proposed using a two dimensional (2D) finite element (FE) model in ABAQUS to apply the initially calculated residual stresses and simulate the cutting process. The deformation at the cut tip can then be estimated for each cutting increment and used to correct the initially measured contour data. The cutting simulation is performed several times until a converged stress solution is reached.

In this research the procedure described above is applied for a CT weld specimen that appeared to show bulge error in the contour method residual stress results. However, a three dimensional (3D) FE model is used for calculating the bulge error which is a more reliable and robust approach (Kapadia, 2017). The CT specimen consisted of a manual metal arc (MMA) weld and an extension piece made from Esshete 1250 which was attached with an electron beam (EB) weld (Traore, 2012) as shown in Fig 1. The previous work on this specimen involved characterising the distributions of transverse residual stress along the measurement line plane measured by neutron diffraction, incremental slitting and contour method as shown in Fig 1. The peak transverse residual stress measured by the contour method was lower than the neutron diffraction measurement by 19MPa (3%) and a slight shift in the location of the tensile peak towards the CT specimen front face was observed.

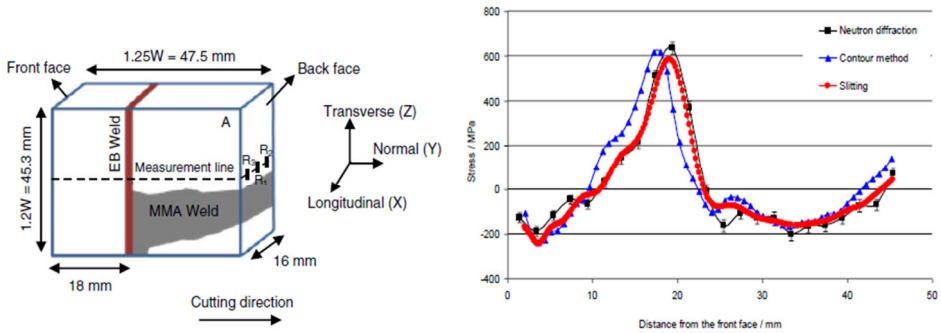

Fig. 1 - C (T) weld specimen with the measurement line and transverse residual stress measured by neutron diffraction, slitting and the contour method. (Traore, 2012)

RESULTS AND CONCLUSIONS

The distribution of transverse stress measured using different techniques for a line profile at mid-thickness of the sample is presented in Fig. 2. The initially measured stresses using the contour method are corrected for the bulge error and are also shown in Fig. 2. A converged stress solution was reached after three iterations. The peak tensile stress was increased from 617MPa to 743MPa (~20%) and slightly shifted towards the back face.

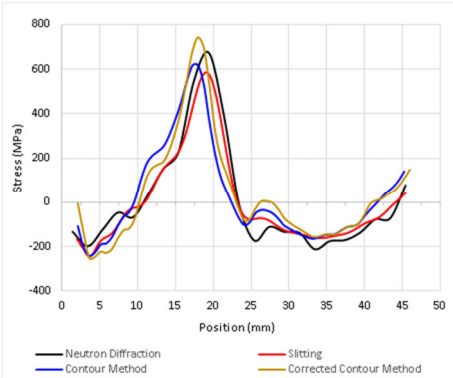

Fig. 2 - Comparison of initially measured stresses with corrected contour method results.

The bulge error can have significant effects on reliable measurements made by the contour method. An iterative FE correction procedure is time consuming and 3D modeling is required in most engineering cases. Further investigating is being carried out within the scope of this PhD research and will be published for an alternative approach to estimate and correct for the bulge error.

REFERENCES

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