Residual Stress Measurements in Steel Beams Using the Incremental Slitting Technique

DZL Hodgson[1], DJ Smith[1], A Shterenlikht[1], MB Prime[2]

[1] Department of Mechanical Engineering, University of Bristol, Queen's Building, University Walk, Bristol BS8 1TR, UK

2. Engineering Sciences and Applications Division, Los Alamos National Lab, Los Alamos, NM 87545

This paper examines the application of the incremental slitting technique for residual stress measurement to plastically deformed four-point bent beams and autogenously edge welded steel beams. Prior to application a series of finite element studies were carried out using Legendre polynomial stress fields to develop the necessary strain release matrix. This was conducted using the SIGINI user sub-routine for the ABAQUS FE code in conjunction with a least squares fit.

This study investigated the effects of the number of polynomials used to define the strain release matrix, the effect of elasto-plastic material properties on the method and the ability of the method to predict linear stress fields. Due to the over-determined nature of the least-squares approach appropriate selection of polynomial series order was necessary to develop the best prediction. When elasto-plastic material properties were used in the FE models very poor strain release matrices were created which lead to incorrect predictions. The effect of these properties in experimental situations also led to errors but this was limited to shallow depths and to gauges situated near the slit.

The specimens used for the plastic four-point bending were manufactured from ferritic steel with dimensions of width 10mm, depth 25mm and length 250mm. This allowed for the use of a plane stress analytical model. These experiments were conducted to allow a better understanding of the incremental slitting procedure and its experimental application. The measured stresses were found to be in reasonable agreement with the FE predictions.

A set of autogenously welded ferritic beams of width 10mm, depth 50mm and length 200mm were also measured. These beams were edge welded to create a through depth residual stress field. Residual stress measurements for two different weld torch speeds were obtained.

We show that a suitably chosen set of polynomials and gauge locations produce residual stress measurements with an uncertainty of about 7MPa. The paper discusses the influence of the number of terms in the polynomial expansion series and the measurement locations.