ISIS Experimental Report

Rutherford Appleton Laboratory

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Title of Experiment:	The use of neutron diffraction to determine the Bauschinger residual stresses in standard ISIS aluminium thick-walled high pressure gas vessels	**Local Contact:**	Shu Yan Zhang
Principal Proposer: Oleg Kirichek **Affiliation:**		**Instrument:**	Engin-X
Experimental Team:	Yanling Ma, Shu Yan Zhang	**Date of Experiment:**	03/03/10-04/05/10

1. Introduction

In order to carry out optimised safe design of any autofrettaged thick-walled cylindrical high pressure cells for the JRA project/ISIS instrument use, the information of the specific positions of the elastic plastic interfaces determined experimentally is vital. The Engin-X instrument of ISIS has the capability of determining such features via measureing the lattice parameters of autofrettaged materials. Several aluminium cells subjected to different autofrettage pressure levels were therefore prepared and measured experimentally.

2. Materials and equipment

Equipment used for the experimental investigation is the ISIS Engin-X instrument. Material selected for the investigation is Aluminium 7075 T6/T6511. The material properties are listed in Table 1.

Table 1 Mechanical properties of Aluminium 7075 T6/T6511

Yield strength	Tensile strength	Elastic modulus	Poisson's ratio
570 MPa	640 MPa	70 GPa	0.33

Note: 1. Material strength indicated in Table 1 are the longitudinal behaviour; 2. Minimum value of the material properties are listed in Table 1.

Using the above material, 6 samples, which have the modified geometries of the ISIS standard aluminium thick-walled high pressure gas vessel, were prepared. All the 6 samples have an outer diameter of 28mm, a major inner diameter of 7mm and an overall length of 100mm. Each of the 6 samples was then autofrettaged with different pressure levels of 0MPa, 200MPa, 400MPa, 500MPa, 600MPa and 700MPa, respectivley. The position of the Engin-X measurement is in the middle section (i.e. 50mm away from either end) of the cell and along its wall thickness.

3. Results and discussions

Residual elastic strains, along the cell wall thickness for all 6 samples were obtained. Two typical experimental results are shown in Fig. 1 for the samples subjected to the autofrettage pressure levels of 500MPa and 600MPa.

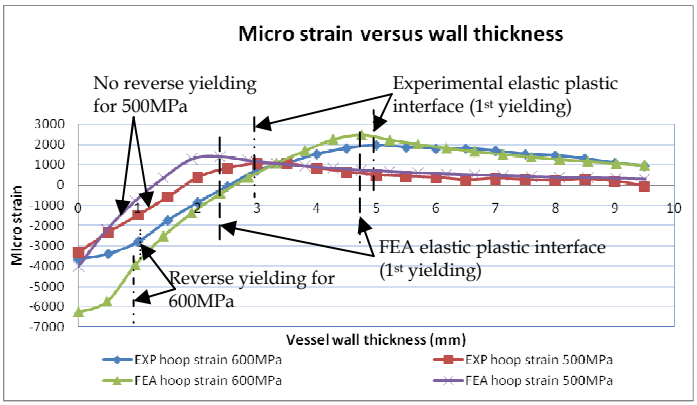

Fig. 1 The results for 500MPa and 600MPa autofrettage pressure

As shown in Fig. 1, after the aluminium cell autofrettaged with 500MPa, the residual elastic hoop strain revealed the 1st yielding only. However, when the identical cell autofrettaged with 600MPa, in addition to a 1st yielding at about 5mm, a reverse yielding resulted from at about 1mm from the cell's inner surface. The later restrains the cell's subsequenct safe/elastic use and need to be avoided.

4. Conclusions

The Engin-X experiment determined the residual elastic strain for all 6 autofretaged aluminium cells successfully; The specific positions of the elastic plastic interfaces were determined via the residual hoop elastic strains measured; The FEA models were also conditioned with the experimental results. Good agreement between FEA and experimental results were achieved; Both the experimental and FEA results are reliable and can be used to carry out the optimised safe design and safe use based on a maximum ultisation of material strength.