ESRF	**Experiment title:** **Residual stresses in shot peened alloys and their modification by faitgue cycling**	**Experiment number**: ME 748
Beamline: ID31	**Date of experiment**: from: 10/10/03 to: 14/10/03 and: 5/12/03 to: 12/12/03	**Date of report**: 7 July 2005
Shifts: 30	**Local contact(s)**: Andy Fitch; Francois Fauth	*Received at ESRF:*

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Report:

The aim of this project was to evaluate the residual stresses in shot peened components and, particularly, the changes that occur during fatigue cycling. Realistic stress information can then be built into an advanced micromechanical crack growth model for fatigue life prediction, and also used to guide the selection of optimum peening conditions for maximum fatigue life. Shot peening induces beneficial compressive residual stresses into the surface at critical locations in highly stressed components, eg. airframes and aircraft engines. It also changes the microstructure in the peened region due to inhomogeneous plastic deformation. Controversy still exists in the shot peening and fatigue community as to whether the major benefits of shot peening should be ascribed to the compressive residual stresses or to microstructural changes which occur over the same region. The work performed in this experiment will help to direct attention towards the correct underlying reason.

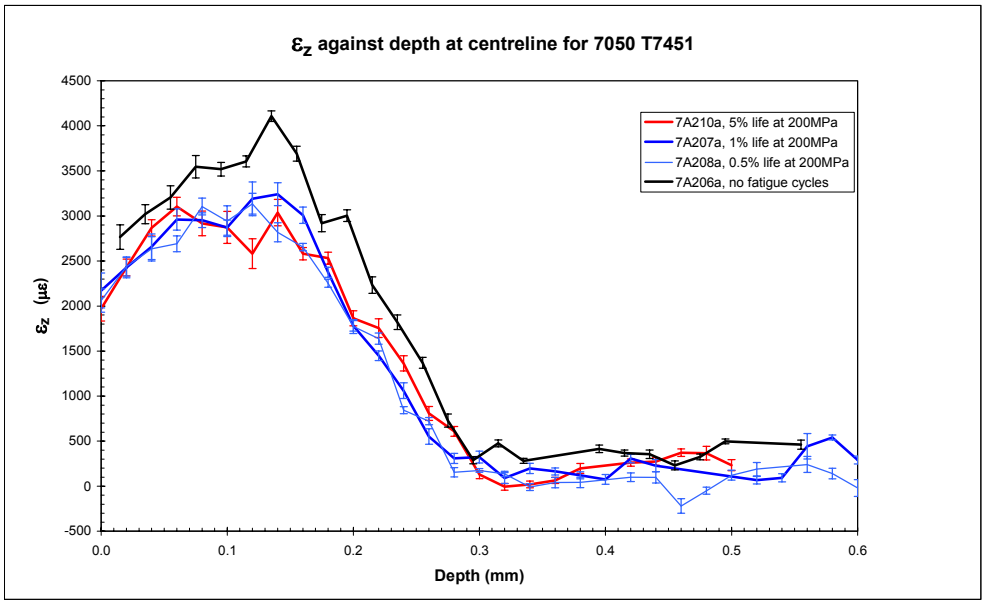
7050-T7451 aircraft grade aluminium alloy was used in this work. Sepcimens 300 mm long by 20 mm wide and 20 mm thick were machined from 25 mm plate using WC tools (tool speed of 15 000 rpm and feed of 0.3 mm/tooth) and 'standard' processes; i.e. one cut of 5 mm to finished surface and tw cuts of 4mm and 1 mm to finished surface. One surface was then shot peened with cast steel shot to peening coverage of either 100% (two passes) or 200% (four passes). Measurements of residual strain and stress were then made on specimens with the following surface conditions:

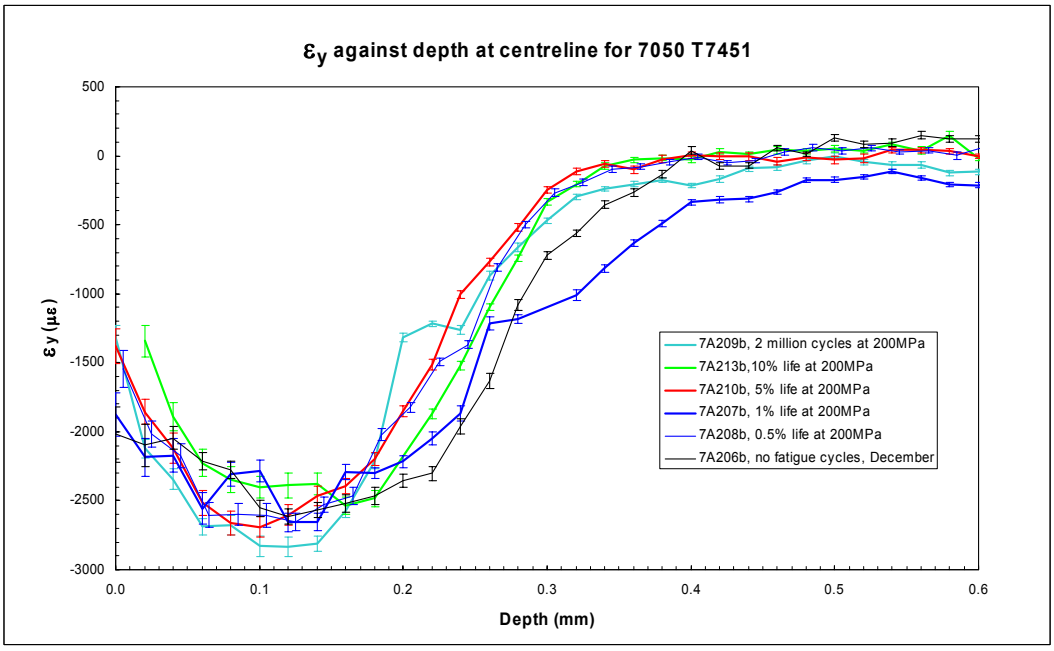
Surface Condition
1 Cut
1 Cut 100%
1 Cut 200%
As Rolled
As Rolled 100%
As Rolled 200%
2 Cut
2 Cut 100%
2 Cut 200%

In the first visit to the ESRF, measurements of strain were made transverse to the surface (ε_z : S-T direction in the plate) and also of the strain along the specimen (ε_y : L direction in the plate) at 20 μm intervals to a depth of around 0.6 mm and then at larger intervals to depths of several millimetres in the plate. The plates were then subjected to fatigue loading at several values of applied bending stress in the range 200 – 275 MPa (44% to 60% of the 0.2% proof strength). Life percentages of 1%, 5%, 10% and 50% were applied to the specimens, based on initially cycling a specimen to failure. In the second visit to the ESRF, the measurements of strain were repeated to determine the stress relaxation that occurred during the fatigue cycling.

Typical data are shown below for the 200 MPa loading case. Individual specimens

have to be compared before and after fatigue cycling, because the specimen-to-specimen variations are of the same order as the changes observed in residaul strain and stress values. This is a fundamental problem with both residual stress measurements and fatigue data and illustrates the advantages accruing from use of a high intensity source and multiple visits to make measurements at the ESRF. The figures below show typical data for the case of a 200 MPa applied load on as-rolled specimens with 200% peening coverage.





A paper has been presented to the Spanish Fracture Group and published in the proceedings of their annual meeting in 2005.

[1] M. N. James, D. J. Hughes, Z. Chen, H. Lombard, D. G. Hattingh, D. Asquith, J. R. Yates and P. J. Webster (2005), **Invited plenary paper:** *Residual stresses and fatigue performance*, Anales de Mecánica de la Fractura (Anejo), Proceedings of the 22nd Conference of the Spanish Fracture Group, Almagro, Spain, 9-11 March 2005 (eds. JC Galvez, EWV Chaves and MJ Casati), 22 pp.9-20, ISSN 0213-3725, also on CR-ROM ISBN:CR-235-05.