ESRF	**Experiment title:** Residual stresses from laser peening of thin aluminium plates	**Experiment number**: MA676
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Report:

Laser shock peening (LSP) is being applied increasingly to aeroengine components, for improved structural integrity. The technique can introduce a deep, compressive residual stress field near the surface of a treated component, which can improve resistance against fatigue, fretting and stress corrosion. The method fires a well-defined laser pulse (in terms of power, duration and dimension) at a surface covered in a film of water. The resulting shock wave is directed into the sample, and the plastic deformation leaves a compressive residual stress.

Aluminium alloys are used extensively in the aircraft industry because of their high specific strength and stiffness which gives lightweight structures. In order to minimize airframe weight, they are often used in thin sections (the fuselage skin may be only ~1 mm in thickness). A useful future application of LSP would be in the introduction of deep (~0.5 mm) compressive residual stresses into aluminium plates of less than 5 mm thickness. This would be of benefit in a wide range of applications, particularly in aerospace, where fatigue of aluminium components is life-limiting.

In this experiment we looked at a range of conditions for laser peening of 2-mm-thick plates. Two materials were studied: aerospace 2024 aluminium alloy, and also 5091, which has advantages for synchrotron X-ray diffraction because of its fine grain size. We were concerned that the 2024 would give poor scattering as a result of its larger grain size and texture, but in the event the results from the 2024 were good.

The initial aim of the eperiment was to look at the through-thickness residual stress profile for the different peen conditions: the primary peen parameter that was studied was the effect of the laser power density on the surface. The desired outcome was a deep compressive stress, and it was hoped that it might be possible to generate a through-thickness compressive stress field with a balancing tensile field of lower magnitude either side of the peen line (analagous to a weld residual stress field).

The results showed that there was often a layer of tensile stress near the surface of the sample. This correlated with results that had been obtained using incremental hole drilling. This effect appeared to persist for all the conditions that were examined. However, the most important result obtained is shown in figure 1, which was obtained after it became clear that the position along the peen line influenced the results that were being generated.

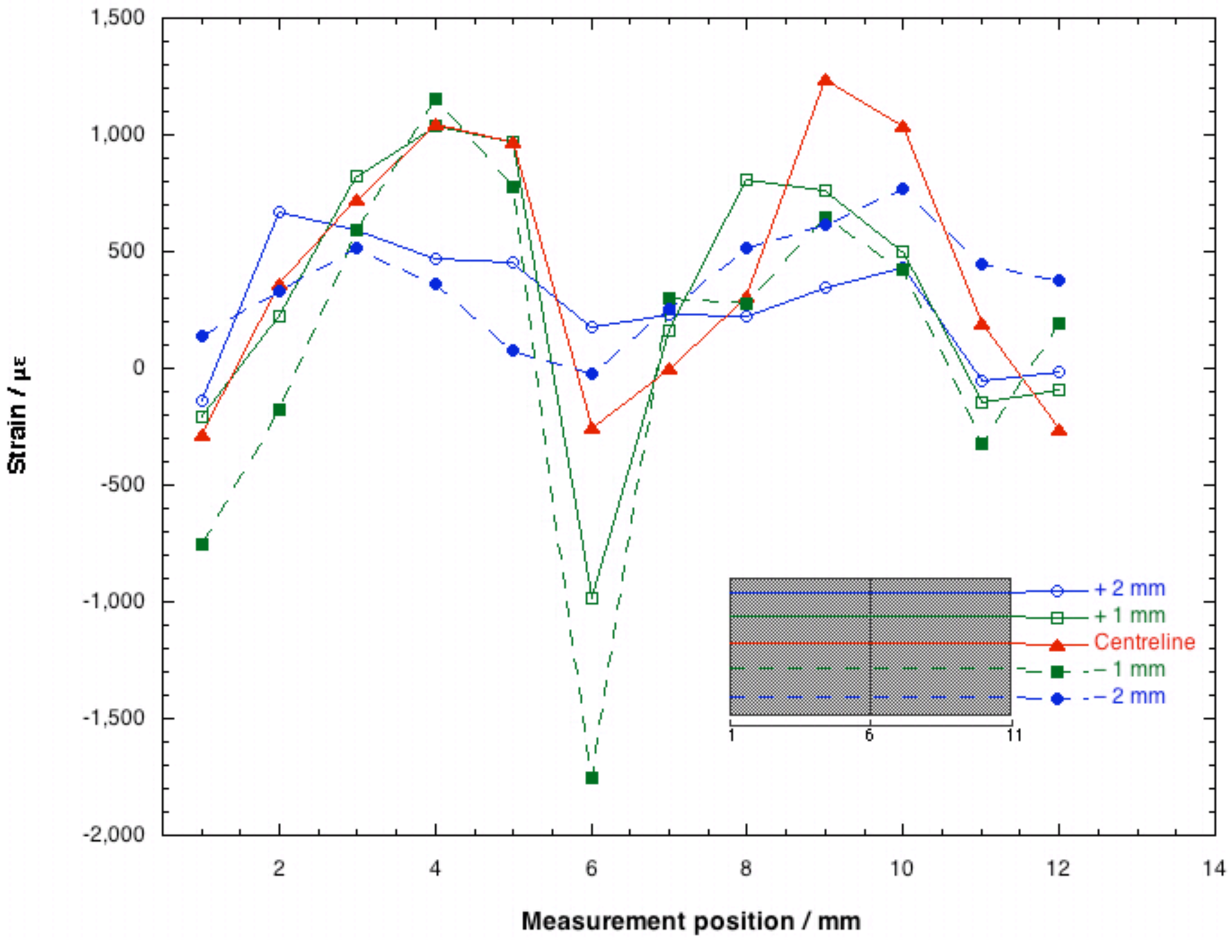

Figure 1

The figure shows the variation of stress along the peened line, from the edge of one peen spot, across the spot, across a second and into a third. The different lines are at different positions in the spot, and all the data were recorded ~120µm from the sample surface. It is clear that the stress distribution is by no means uniform: whilst the strains are compressive at the spot edges, they are tensile in the centre; there also appears to be a significant variation in the strain magnitudes from spot-to-spot, which is unexpected. It is clear that the peening is not having the required effect.

Furthermore, the data correlates extremely well with the profile of the fatigue crack grown in samples peened using this treatment, and a paper is in preparation summarizing these effects.
Further work is under way to identify how this effect occurs and how it can be removed. We are examining reducing the peen power and using multiple peen layers.