Residual Stress Measurements at Macro- and Micro-Scales Using DIC

Introduction

The measurement of residual stresses is a very active research area. The most commonly used technique currently is the crack compliance, or slitting, method. This involves the introduction of a slot in a material under stress and measuring the relaxation caused. This application note summarises work carried out by the Mechanical Engineering department, University of Bristol, using Dantec's Q-400 Digital Image correlation (DIC) system and ISTRA 4D software. The full field, non-contact technique of DIC can be used to measure the relaxation at both macro- and micro-scales.

Macro-scale measurement

For the macro-scale work a tri-layer bonded aluminium sample was used, the middle layer being in tension and the outer layers in compression. The relaxation was done with a slitting saw at 0.25mm increments. Dantec's Q-400 system was then used to measure the full field 3D displacement and strain at each increment over an area of a few square millimetres. A pair of LDVT's were used to reposition the sample to an accuracy of 10µm, this significantly reduced rigid body motion. See figure 1 for the experimental setup.

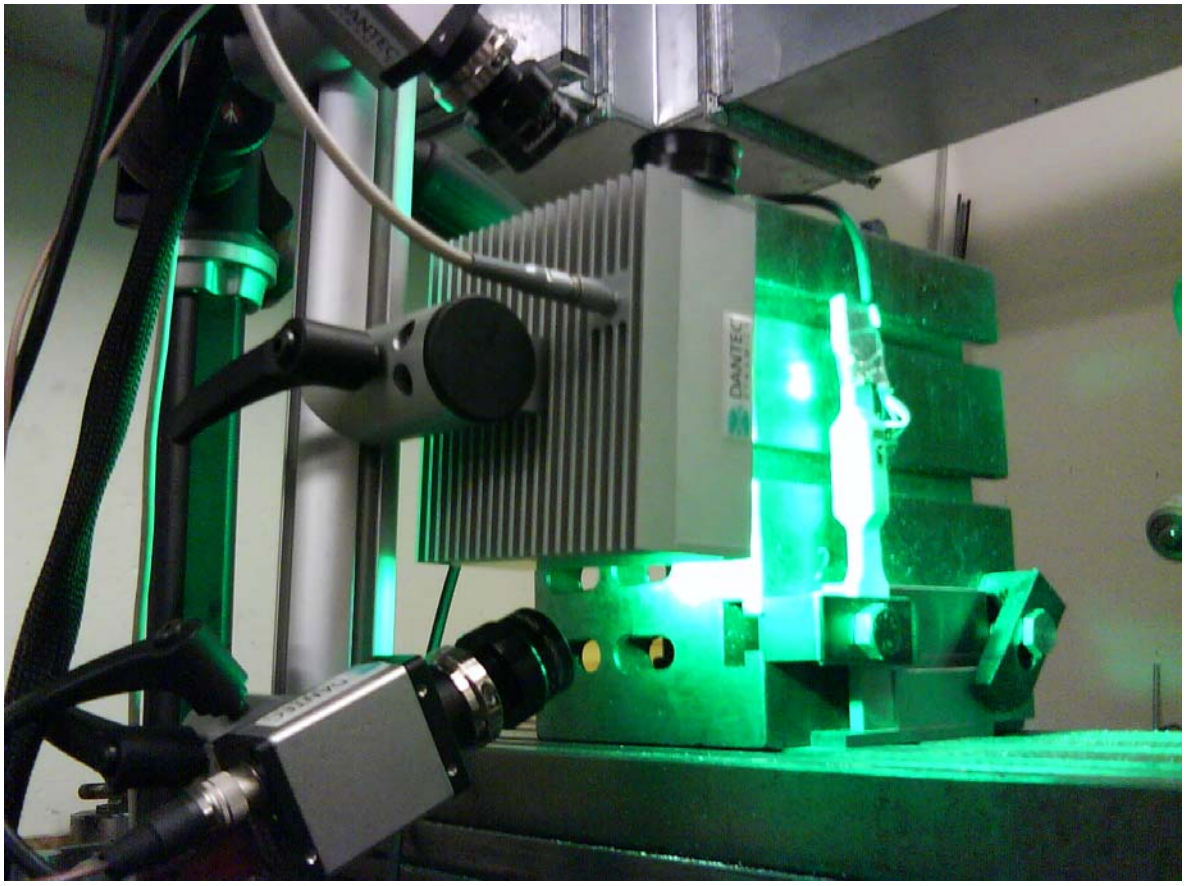

Figure 1: Macro experimental setup.

Micro-scale measurement

For the micro-scale work a focused ion beam (FIB) instrument was used both for the imaging and slotting. A FIB is similar to a scanning electron microscope (SEM) however it uses a gallium ion beam rather than an electron beam. 40% zinc brass heat treated samples were used and it was found that mechanically polished samples produced a pattern for the DIC to work from.

The samples were placed in uniaxial compression and images acquired before and after the slot of 20µm across a grain boundary had been cut. These 2D images could then be easily imported into Dantec's ISTRA 4D software for analysis of full field displacement and strain.

Figure 2 shows the before and after images of the sample and Figure 3 shows the relaxation in the vertical direction, note displacements are in pixels. Finally figure 4 shows data extracted at lines parallel to the slot with displacements shown in pixels and nanometres.

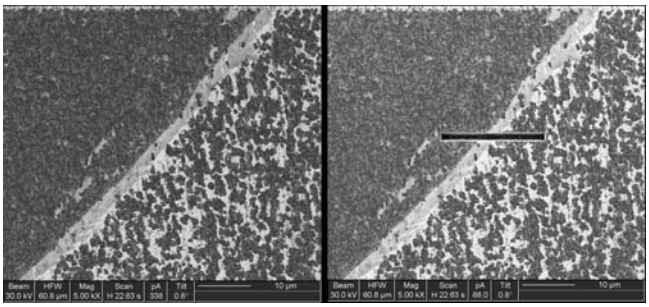

Figure 2: Before and After slotting FIB images

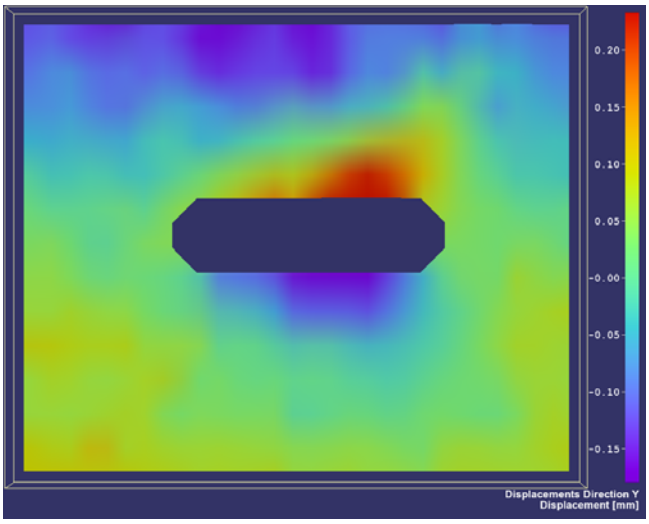

Figure 3: DIC vertical displacement results

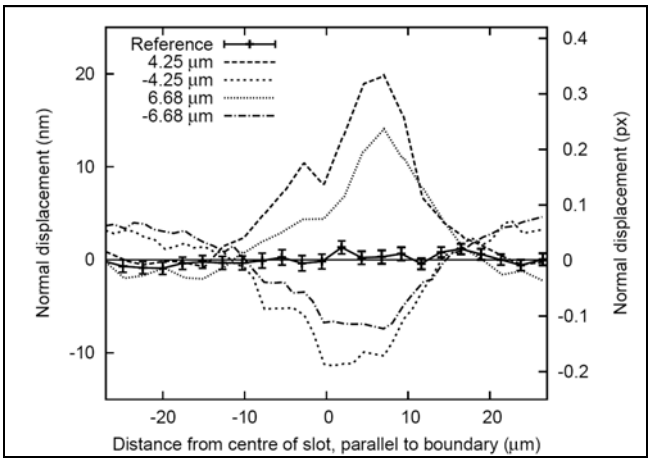

Figure 4: DIC vertical displacement results

References/Acknowledgments

Residual stress relaxation measurements across interfaces at macro and micro-scales using slitting and DIC

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Micro-scale residual stress relaxation measurements using focused ion beam slotting and digital image correlation

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