FLUID STRUCTURE INTERACTIONS RESEARCH GROUP

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Applications of Thermography for Material and Structures Monitoring and Assessment

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Thermoelastic Stress Analysis

Thermoelastic stress analysis (TSA) technique is a non-contacting and non-destructive technique for obtaining full-field stress data using the following relationship:

$$\Delta T = -\frac{T\alpha}{\rho C_p}\left(\Delta\sigma_1 + \Delta\sigma_2\right) \qquad (1)$$

where ΔT is the change in temperature, $\Delta\sigma$ is the change in stress, α, ρ and C_p are material constants and T is the mean surface temperature. Changes in stress produce a small change in temperature measured using infra-red (IR) detectors.

By looking for stress concentrations, it is possible to identify the presence of near surface damage. This technique is being used to evaluate the development of fatigue damage in composite materials.

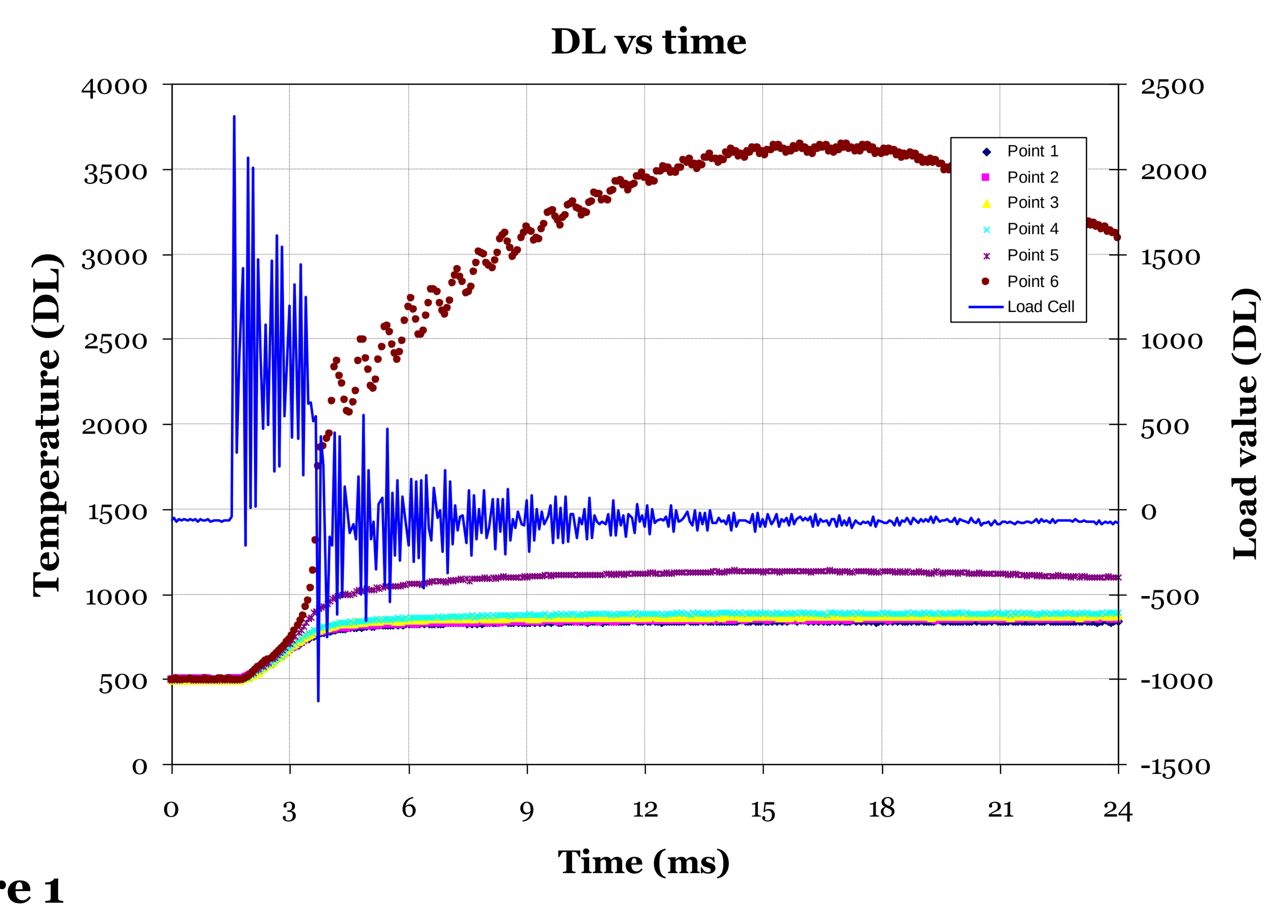

Figure 1

Energy Release During Failure

When fibre reinforced composites fail there is a release of energy due to a combination of viscoplastic heat generation and the formation of new surfaces. During a fatigue test, the formation of fatigue cracks in the matrix (typically in plies orientated at 90°) leads to a pulse of heat that can be measured at the surface, as shown in Figure 2 for a cross-ply specimen loaded in tension. The area under the curve and the shape of the rise provide information on the severity (magnitude of energy released) and depth of the damage.

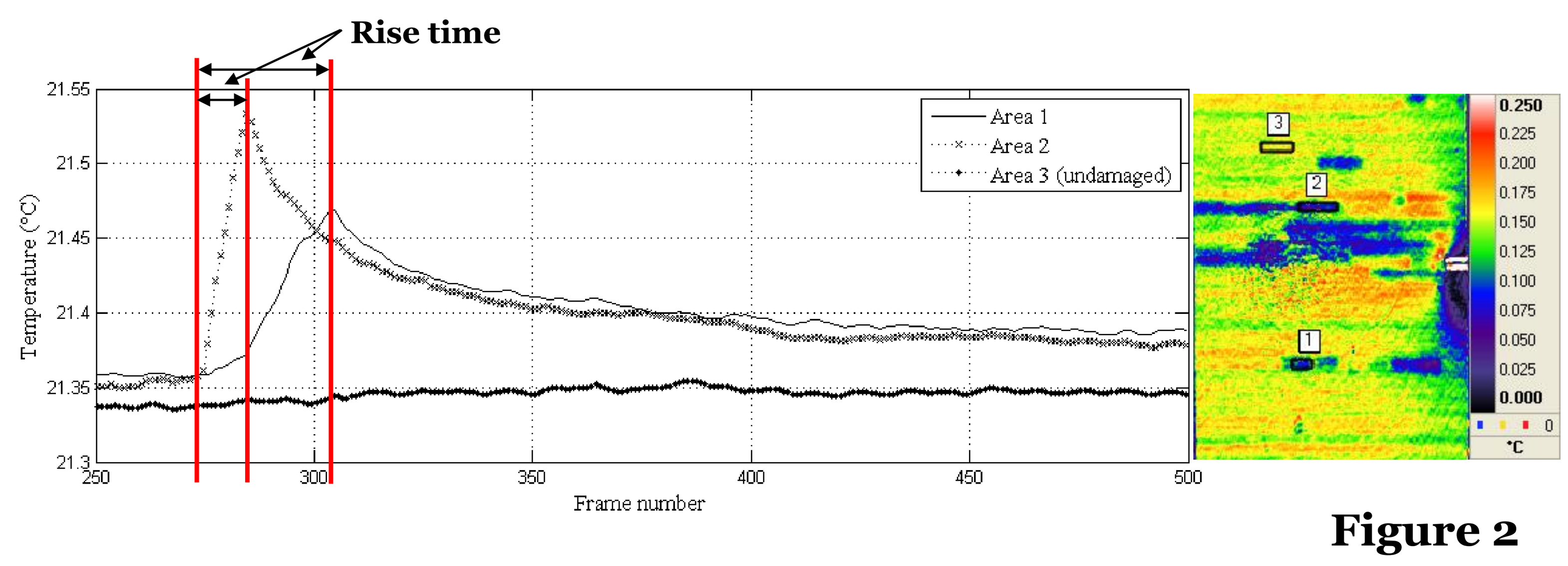

Figure 2

High Speed Material Characterisation

The mechanical response of a material to an applied load or strain is dependent on the rate at which a load or strain is applied. The behaviour of composite materials under high speed deformation, such as during collisions or foreign body impacts, is currently not well understood. IR thermography is being used to measure the heat generated during a high speed deformation

Figure 1 shows an example of the temperature evolution at four points in a steel specimen (point 6 is adjacent to the fracture location in the specimen). The area under the curve is related to the energy released during the event.

Thermal Degradation of Foam Cored Sandwich Panels

PVC foam cores, commonly used in many sandwich structure applications, loose their stiffness at elevated temperatures. As a result, the thin face sheets loose the out-of-plane support provided by the core. Under bending loads, the compressive face sheet is liable to buckle, changing the failure mode of the structure.

A rig (shown in Figure 4) has been designed to validate a higher order sandwich panel model which was developed at Aalborg University to study the mechanical response of such structures under elevated service conditions. The rig is designed to apply specific boundary conditions while providing full-field access for IR and optical measurement.

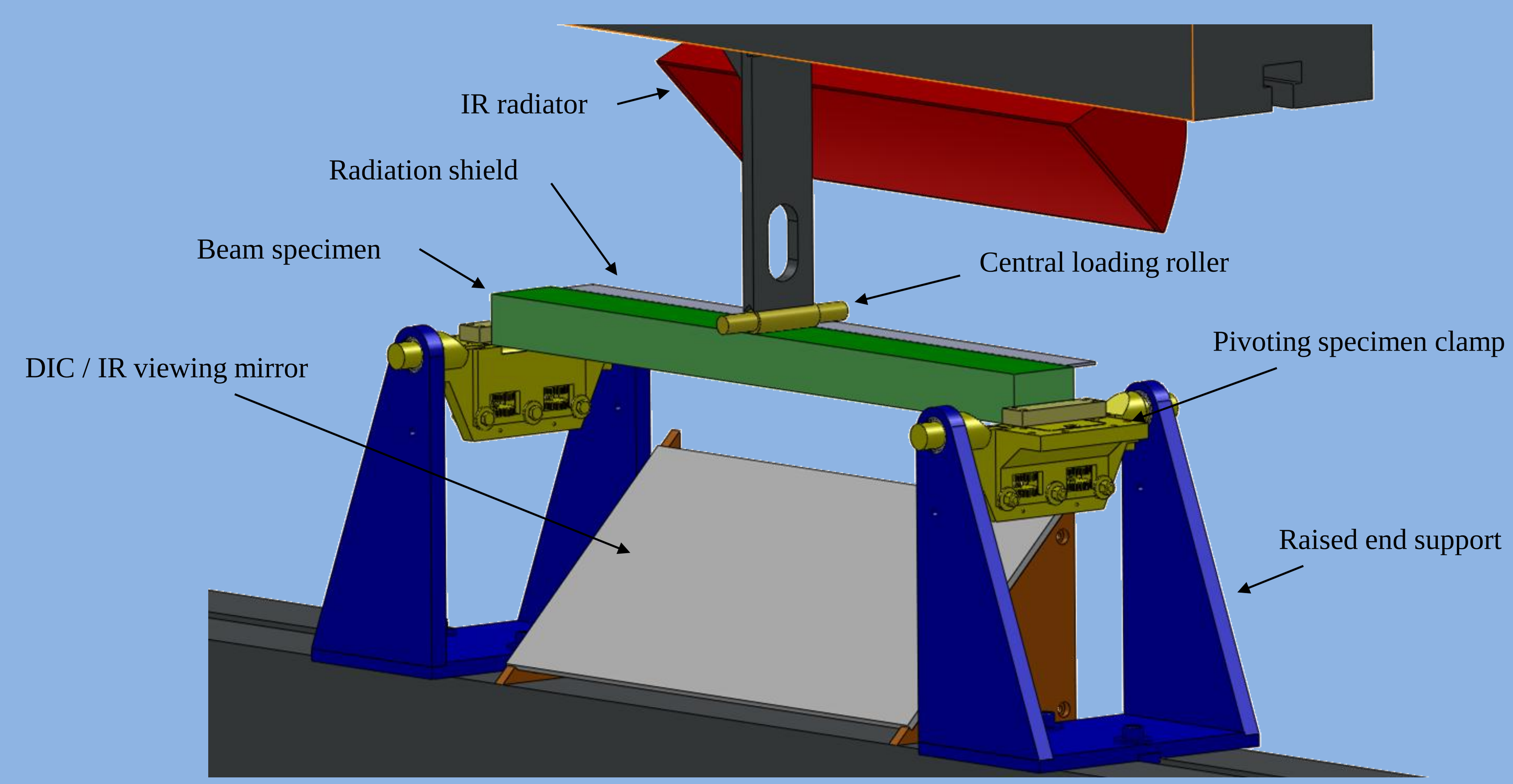

Figure 4

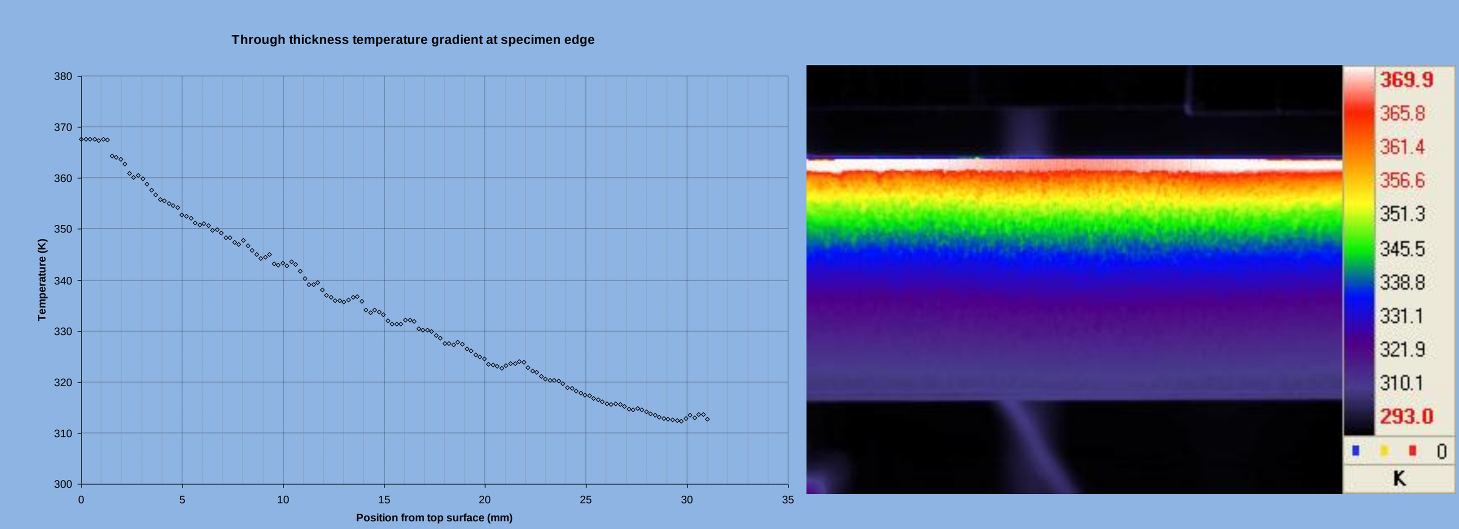

Figure 5

Figure 5 shows a linear temperature profile through the thickness of a beam specimen with aluminium face sheets. The resulting deformation (localised indentation) shown in Figure 6 corresponds with model predictions.

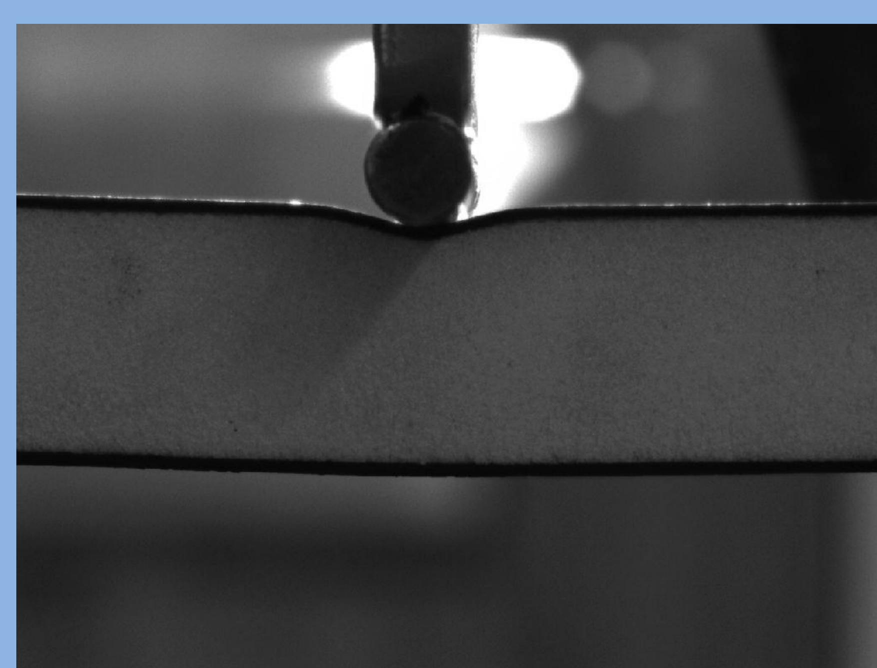

Figure 6

Acknowledgements

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