FLUID STRUCTURE INTERACTIONS
RESEARCH GROUP

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High-speed thermography for damage assessment during high strain rate testing

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Background:

Composite materials are being used by the military in land, sea and air vehicles to reduce weight to assist with speed and manoeuvrability. Collisions or blast loads cause high strain rate events to occur, that may cause the composite structure to fail completely or to suffer damage that reduce service life – possibly leading to sudden unexpected failure.

To reduce the risk of catastrophic failure after a high strain rate event it is important to fully understand the structural performance of polymer composite materials and structures under such loading. Infra-red thermography will be used to help characterise composite materials at high strain rates to .

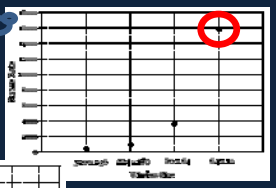
Infra-red Thermography (IRT):

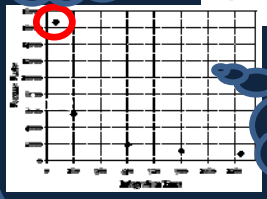
- **Aim** - to obtain the full field temperature evolution during high strain rate loading to inform a thermomechanical material model
- **Detector** - Cedip Silver 480M IR camera
  - 320 x 256 pixels at 383 Hz
  - Temperature resolution 20 mK
- **Challenges**
  - Acquisition frequency
  - Resolution reduction
  - Non-uniformity corrections
  - Equipment calibration

Acquisition frequency:

- Infra-red detector measures emitted radiation from a surface to find the temperature.
- To increase the acquisition frequency a reduction in integration time (IT) is required however a shorter IT leads to less photons to be measured.
- A further challenge is provided by the need to sub-window the detector for higher frame rates due to data transfer.

Window Size
- Compromised at 64 x 12

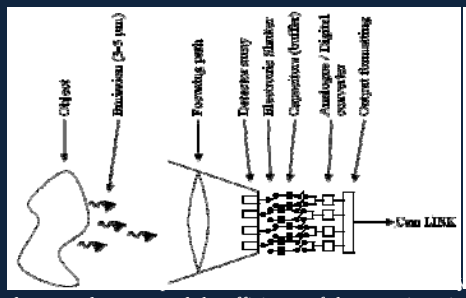


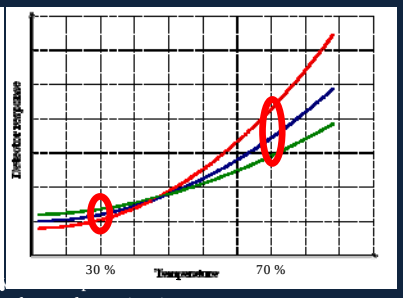


Integration
- Compromise at 60 µs
- Allows ~ 15 kHz

Importance of non-uniformity correction (NUC):

The system uses 1 detector array with 2 banks of capacitors to maximise the sampling rate. The detector elements and capacitors each have slightly different performance. A 2 point NUC is therefore needed. This is done at approximately 30 and 70% of the desired temperature range.





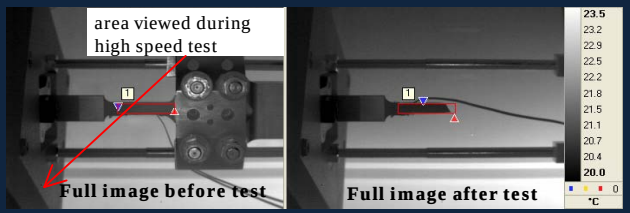
detector elements and the efficiency of the capacitors in the read-out circuit.

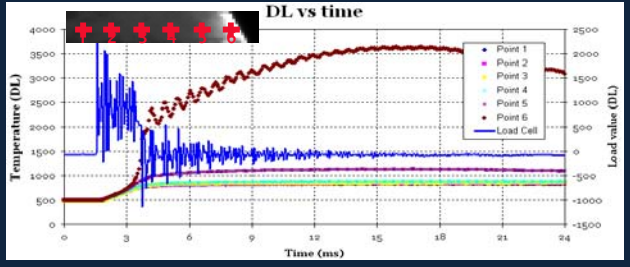
- Example image without 2 point NUC
- Many pixels read zero

- Example image with 2 point NUC
- Only natural variation visible

Initial high speed IRT on steel:

- A steel dog bone specimen with a gauge length of 50 mm was tested at 10 m/s using a servo-hydraulic test machine.
- The IR camera was run at 15 kHz with a 64 x 12 window and an IT of 60 µs.
- The plot on the right demonstrates the potential to measure the thermoelastic temperature change during the test (points 1-5) and also the heat released at the failure site (point 6).
- There is a strong indication that during failure a significant amount of heat is produced.





Future work:

- Conduct a range of tests on steel specimens at actuator speeds 1 – 20 m/s and optimise detector settings for each speed.
- Develop specific calibration curves for a range of frame rates optimised for each test speed.
- The technique must then be proven on glass and carbon fibre / epoxy specimens.
- Final objective of project is to combine IRT with digital image correlation on white light high speed images.
- Produce a synchronised method for consistently recording DIC and IRT data from composite specimens.

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