Multi-scale Analysis for Facilities for Energy Storage (Manifest)

– Facilities for material characterisation at Loughborough university

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DSC

TA Instruments Discovery Differential Scanning Calorimeter (DSC)

+ RCS90 Cooling system

- Temperature range = -90-550°C

- Maximum sample size = 4mg

- Purge gas = Nitrogen

- Auto sampler with 50 sample locations

- Can conduct Modulated DSC (MDSC) experiments to separate reversing and non-reversing heat flow of samples.

- Device suitable for measuring heat flow transitions of materials with time or temperature. i.e.;

  - **Phase transitions , Sensible enthalpy, Dehydration enthalpy , Glass transition , Decompositions**

TGA + RGA

TA Instruments Discovery ThermoGravimetric Analyser (TGA)

+ MKS Cirrus 2 Residual Gas Analyser (RGA)

- Temperature range = Ambient - 1200°C

- Maximum sample size = 4mg

- Purge gas = Nitrogen

- Auto sampler with 25 sample locations

- Device suitable for measuring mass change with time and temperature and to determine the AMU of disassociated material from the sample using the RGA i.e.;
  - Decompositions, Dehydrations

TMA
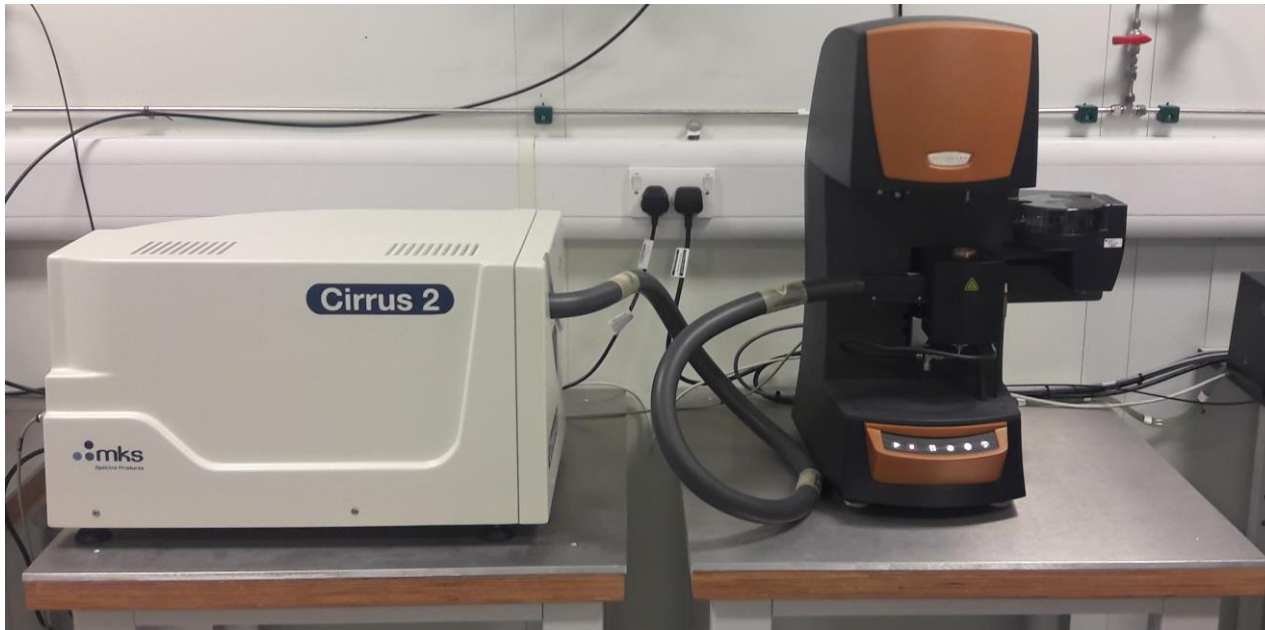
TA Instruments Q400 ThermoMechanical Analyser (TMA)

- Temperature range = -150 - 1000°C

- Maximum sample size = 26mm length x 10mm Diameter.

- Force range = 0.001 – 2N

- Purge gas = Nitrogen

- Can conduct Modulated TMA (MTMA) experiments for separate reversing and non-reversing dimension changes.

- Device suitable for measuring thermal transitions of materials with time or temperature. i.e.;

  - Thermal expansion, thermal contraction, softening point.
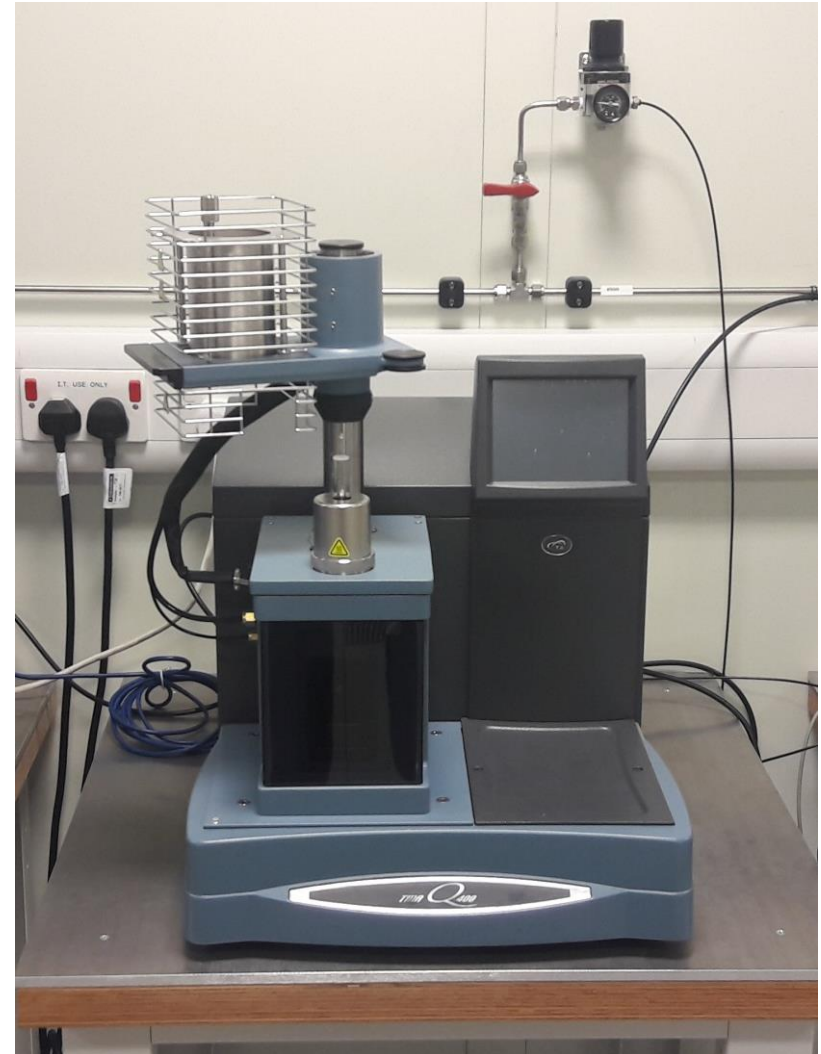
Dilatometer

TA Instruments Differential Dilatometer DIL 802

- Temperature range = Ambient -1700°C

- Maximum sample size = 10mm diameter, 50mm length

- Maximum change in length = 4mm

- Can test samples in a air, inert gas or vacuum

- Device suitable for measuring thermal transitions of materials with time or temperature. i.e.;

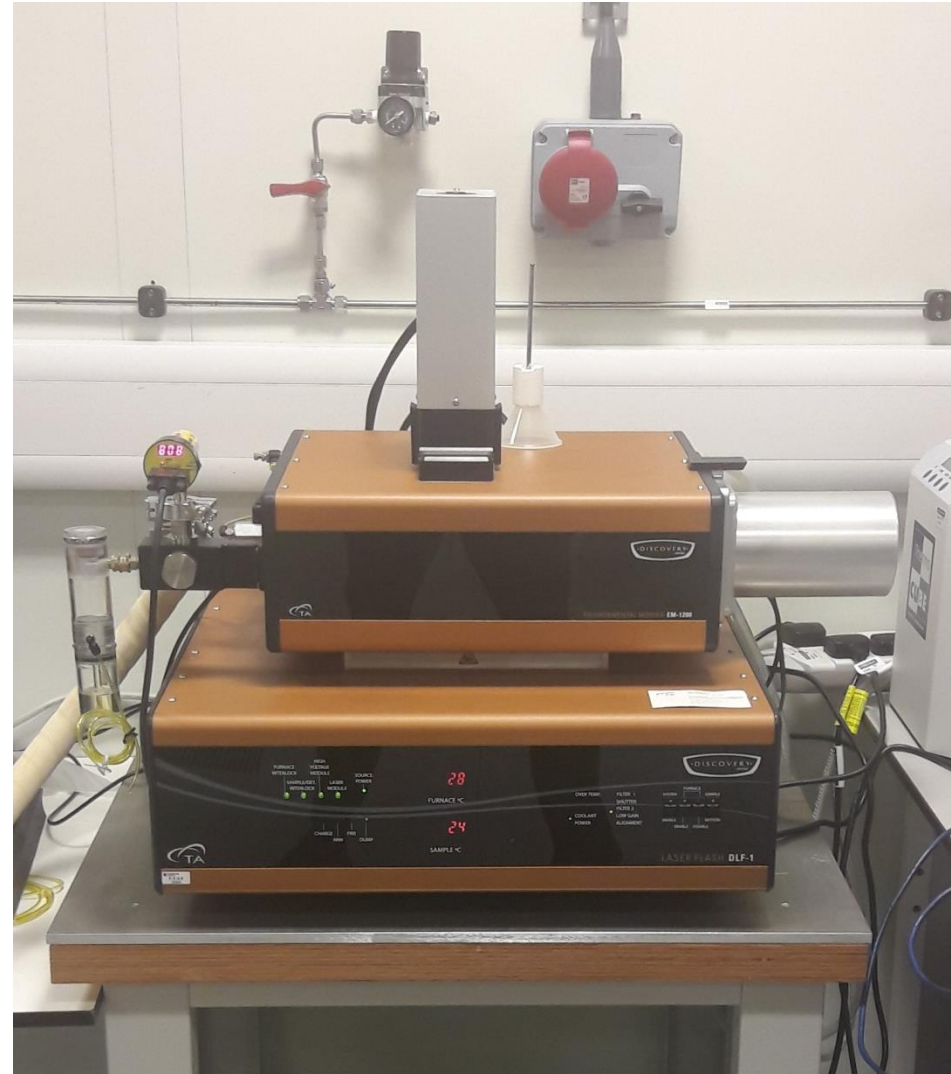 - Thermal expansion, thermal contraction, softening point.

Laser Flash

TA Instruments Discovery Laser Flash DLF 1200

- Temperature range = Ambient - 1200°C
- Maximum sample size;
  - Round = up to 25.4mm diameter
  - Square = 10mm in length
  - Maximum thickness = 10mm
- Device suitable for measuring thermal diffusivity and thermal conductivity of materials.

Rheometer

TA Instruments Discovery Hybrid Rheometer

- Used to measure deformation and flow of a material with changing environmental conditions and force.

- Temperature range = -45- 200°C (with dual Peltier plate)

- Up to 40mm diameter sample size

- Maximum Torque = 150 mN.m

- Can identify;

    - Phase transitions

    - Changing viscosity

    - Glass transition

SEM + EDX

Hitachi TM3030 table top Scanning Electron Microscope (SEM) with attached Energy Dispersive X-ray spectroscopy (EDX)

- Observation conditions = 5kV, 15kV and EDX

- Magnification = from 15x to 60,000x

- Maximum sample size = 70mm diameter, 50mm height

- Sample stage can be moved while viewing sample.

- EDX allows for material composition characterisation via image mapping, spot mode or a line scan of changing composition.
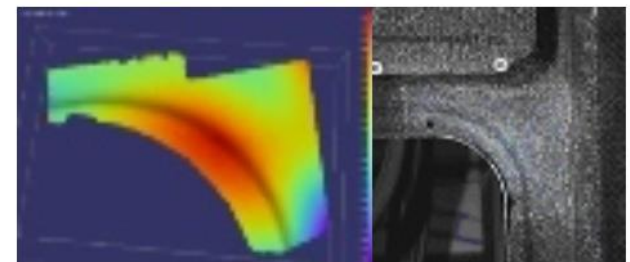
Digital Image Correlation (DIC)

Dantec dynamics Q-400 DIC system

- 3D optical non-invasive measurement system

- Real time data evaluation

- Used for determination of 3D changing material properties

  - Component testing – shape, displacements, strains

  - Material testing - (Young's modulus, Poisson's ratio, Elasto-plastic behaviour)

  - FEA validation

Deformation analysis on the corner of a carbon fibre reinforced structure

Dantec dynamics Stereo PIC (2D3C PIV) system

- System uses a non invasive optical laser measurement method to study flow, turbulence and microfluids

- 2D3C = 2 dimensions, 3 components = Velocity measurements of a fluid in a 2D plane with 3 velocity components using a stereo camera setup

- Our system has two 4MPixel, 400fps (at full resolution) cameras for stereo PIV.

- Large interlocked enclosure for conducting large experiments (see image below)

- Velocity range = 0 – supersonic (i.e. ~343m/s)

- Results calculated and presented in real time

- Results can be used to verify CFD models
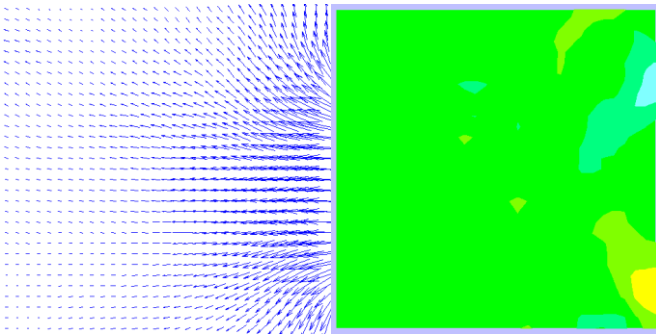
Animation of vortex pair from a pump exit. The animation is generated directly from the DynamicStudio database

Heat Sources

A range of Huber heat sources available

510 Unistat with Pilot ONE

- Temperature range = -50-250°C
- Temperature stability = +/- 0.01°C
- Heating power = 6kW
- Water and air cooled systems
- Max flow rate = 105 l/min (1.5bar)

TR401 Unistat with Pilot ONE

- Temperature range = 50-400°C
- Temperature stability = +/- 0.05°C
- Heating power = 3/9kW
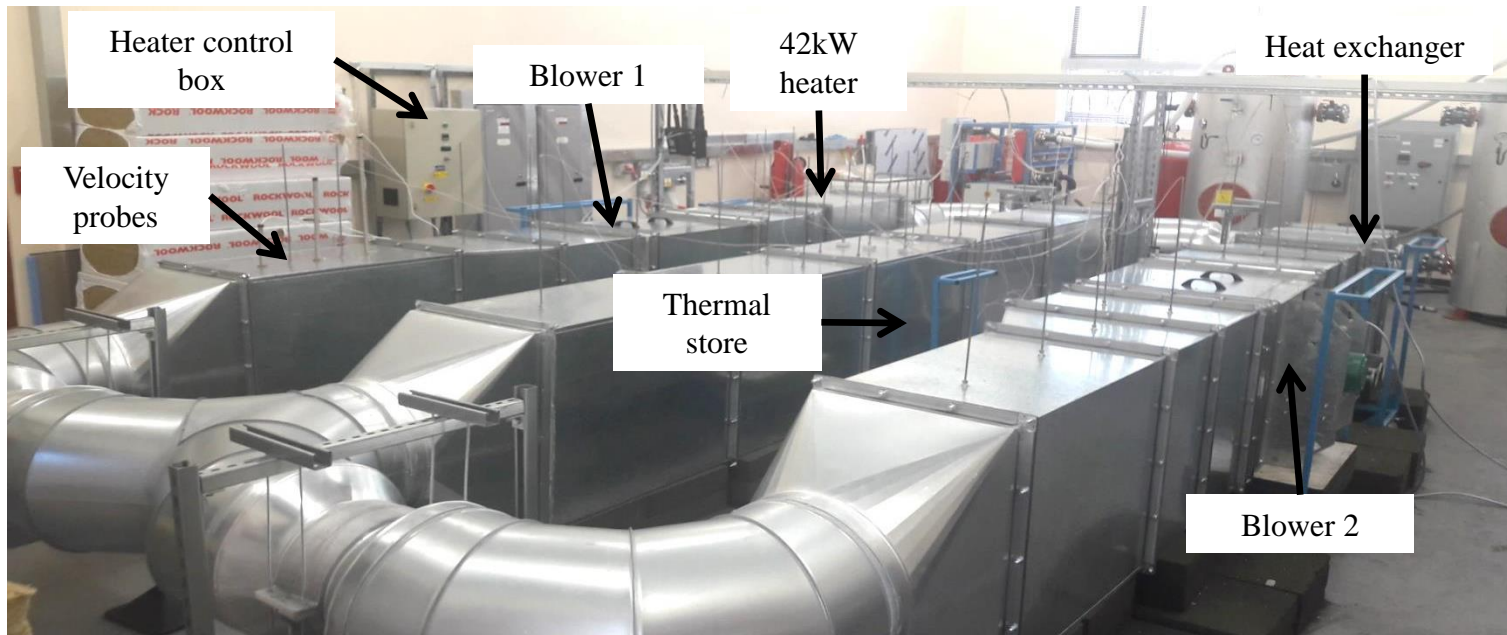- Water cooled system
- Max flow rate = 26 l/min (0.8bar)

Unistat Tango with Pilot ONE

- Temperature range = -45-250°C
- Temperature stability = +/- 0.01°C
- Heating power = 0.7kW
- Air cooled system
- Max flow rate = 55 l/min (0.9bar)

Large thermal characterisation rig

- Temperature range = Ambient-350°C
- Maximum sample size = 1m x 0.55m x 0.8m.
- 42kW Air heater
- 2x air blowers
- 3 lane system for charging and discharging.
- Internal air to liquid heat exchanger for connection to water tanks for store discharge
- Two water tanks connected ORC for electricity production.

Thank You!

Any Questions?