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COMPOSITE MICROMECHANICS BY SYNCHROTRON X-RAY IMAGING & STRAIN MAPPING

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Professor Withers discussed his work whose aims are:

- To image growing fatigue cracks growing through matrix of a metal matrix composite
- To understand crack bridging by fibres in the metal matrix
- To understand the role of the matrix/fibre interface
- To identify what happens if there is an overload
- To identify what happens if fibres break

His main experimental tools in achieving these aims are:

- X-ray tomographic imaging of behaviour
  - Imaging of crack growth
  - Identify damage accumulation
  - Measure extent of opening of cracks
- Strain mapping by X-ray diffraction
  - To measure the stresses in bridging fibres
  - To measure the interface strength between matrix & fibre
  - To measure the redistribution that occurs if a fibre breaks

Professor Withers discussed the advantages of 3D tomographic imaging over traditional 2D imaging using animations obtained from a sample obtained from a box which had contained teabags (supplied by the programme secretary). The coating, chemical pulp and mechanical pulp layers and key features of their structure were clearly distinguishable.

He then went on to describe the use of X-ray diffraction as an "atomic strain gauge" taking advantage of the shifts in diffraction peaks caused by changes in spacing of atoms. He showed images and animations illustrating the use of this method to monitor how strains build up in a composite before failure. In particular, the interface between reinforcing fibres and matrix is of crucial importance. Whether the interface is too strong, too weak and whether it allows sliding can be determined.

As an example of a problem which can be investigated using these tools, Professor Withers described an investigation into crack bridging in a fatigued, multi-ply composite. Samples were prepared with fatigue cracks which had progressed past 2 rows of fibres. The crack could be imaged using tomography and the local strains monitored on a fibre-by-fibre basis. This allowed details of interfacial strength and the size and effect of sliding regions to be determined. Bridging fibres shield the crack tip from the full fatigue load. Fibre sliding occured over approximately 1 *mm* of fibre length and led, in this case, to a decrease in interfacial strength from 200 *MPa* to 60 *MPa*.

A second example concerned tomographic imaging of crack opening displacements. This investigation shows how cracks progresses in relation to positions of reinforcing fibres. The hysteresis between crack opening and closing during a fatigue cycle can be monitored and the permanent crack opening resulting from overload can be seen.

Prof Withers' final example examined what happens when 3 fibres break in a composite. The investigation used tomographic imaging and strain mapping to show how stress is propagated in the structure.