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Light for Science

Engineering

overview

Companies within the engineering industry are continually looking for new ways to advance their performance and gain a lead over the competition. One of the best ways of achieving this is to develop a greater understanding of how components are affected by production processes and treatments and how products and systems cope when exposed to strain, ageing, fatigue etc.

As the field of synchrotron research has matured and expanded from traditional sciences into applied engineering, experts have developed highly innovative and specialised ways to meet the challenges presented by the different types of experiments that the growing user community wish to embark on.

Key Challenges

- **Strain, crack and corrosion reduction**
  Using hard X-rays to penetrate into the bulk of components and processing devices, the nature of defects and stresses can be shown deep inside
- **In-situ studies during processing.**
  By studying materials during processing in real time, diffraction and imaging can be used to identify optimum processing capabilities
- **Processes in controlled environments.**
  Understanding how heat, pressure, and ambient gases affect the process can lead to improvements in the material's performance.

The Synchrotron Solution
The high intensity of synchrotron X-ray beams enables more information to be gathered and analysed than traditional laboratory techniques. Higher energies permit the gathering of data from deeper within the material.
The time scale for experiments are reduced dramatically in comparison to laboratory based techniques.

Techniques
The Joint Engineering, Environmental and Processing beamline (JEEP) will be a multipurpose facility providing high intensity diffraction and real-time imaging and tomography for large engineering components up to the scale of 1 metre.

A purpose built laboratory will allow in-situ measurements using small pilot plants.

Atomic ordering in electronic and magnetic materials can be studies using the Materials & magnetism beamline, while the Extreme conditions beamline will offer single crystal and powder diffraction experiments under high pressures and temperatures.

Beamlines: I12 JEEP, I15 Extreme Conditions and I16 Materials & Magnetism

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case studies

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Reality checking

A key aspect of testing aircraft components is being able to replicate operational conditions. This requires a large sample volume to contain, for example, part of an aircraft wing. In addition it is necessary to be able to mimic the high temperatures and large forces that engine components will experience in flight. Finally it is necessary to study systems over long periods of time – several hours or even days.

Dr Alexander Korsunsky at the Department of Engineering Science at the University of Oxford has been working with Rolls-Royce, a leading manufacturer of aeroengines for Boeing and Airbus planes. He has helped them develop innovative techniques using synchrotron light.

In a number of research and development projects conducted by Rolls-Royce heat treatment procedures were sought that would minimise the residual stress within combustion system components. In a collaborative experiment with Dr Korsunsky's group, conducted at the ESRF using high energy X-ray diffraction, a family of components were studied that had undergone different heat treatment procedures. As a result the researchers found that a particular procedure resulted in the optimal reduction of residual stress, giving Rolls-Royce the processing capability that they set out to establish.

Mike Walsh from Rolls Royce, Combustion Systems, comments, "Knowledge of residual stresses in large, complex engineering structures relies on high energy radiation sources for beam penetration. Such work provides the foundation for the laboratory techniques that are being developed at the Rolls-Royce UTC in Solid Mechanics at the University of Oxford under the guidance of Dr Alexander Korsunsky"

Source Dr Alexander Korsunsky
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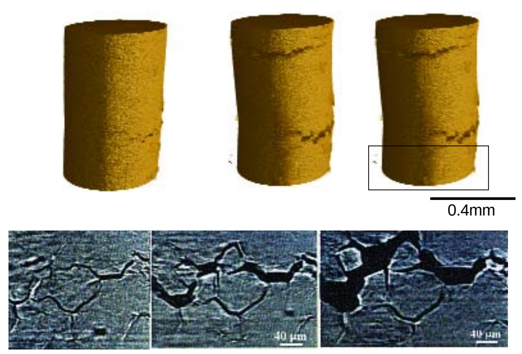
Imaging cracks

Dr James Marrow at the University of Manchester has been leading a team, supported by Rolls-Royce, BNFL and Serco Assurance, working on imaging intergranular stress corrosion cracks. The work, which will lead to safer nuclear plant, makes use of synchrotron beams to provide detailed 2D and 3D images. This means very high spatial resolution can be achieved (>1µm). The technique is non destructive so the researchers have been able to use it to produce successive 3D pictures showing the growth of stress corrosion cracks in pressure vessel stainless steels.



The pictures show the exterior view at three stages of corrosion crack growth through a wire, and corresponding internal slices cut through the virtual 3D image. The crack grows preferentially along grain boundaries but some are resistant to corrosion and must be plastically broken. Dr Marrow explains "Using these images, we have been able to understand how bridging ligaments span the crack and help to hold up its progress. In this way it may be possible to 'engineer in' many such bridges and so prevent the crack propagating".

Source: Dr James Marrow
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