Neutron Strain Measurement

MANCHESTER 1824
The University of Manchester

STRESS & DAMAGE CHARACTERISATION UNIT

Diffraction is capable of measuring atomic lattice spacings very accurately, allowing their use as an 'atomic strain gauge'. Neutrons are characterised by very large penetrations into most engineering materials (see table). As a result neutron diffraction acts an atomic strain gauge, capable of providing three-dimensional maps of strain to significant depths in engineering components.

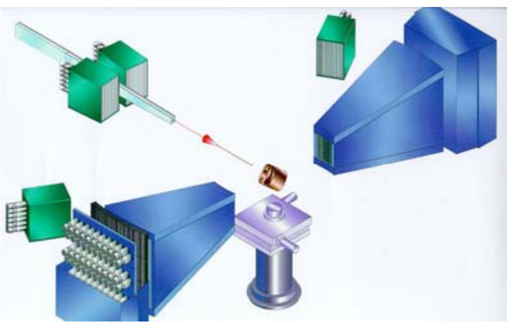
Facilities

Neutron diffraction is carried out at central research facilities. Within Europe beam-time is available under peer review application procedures. The Unit is coordinating the building of a new £1.6M strain scanner at the Institute Laue Langevin (ILL) and is a partner in the building of ENGIN-X (below), a new £2M instrument at ISIS. The Unit regularly obtains beam time for experiments at ISIS (Didcot), ILL (Grenoble), Risø, (Denmark), Saclay (Paris), Studvik (Sweden) and Chalk River (Canada).

Capability

At present spatial resolution is limited to 0.5 mm with gauge volumes greater than a cubic mm for neutron diffraction; depths are limited to those in the table for economic reasons. Currently an expert worldwide panel, chaired by Prof G.A. Webster of Imperial College is defining industrial standards for repeatable measurements (VAMAS TWA 20).

Economic Penetration Depth	
Aluminium	250 mm
Steel	37 mm
Copper	40 mm
Titanium	27 mm
Nickel	24 mm
SiC	200 mm

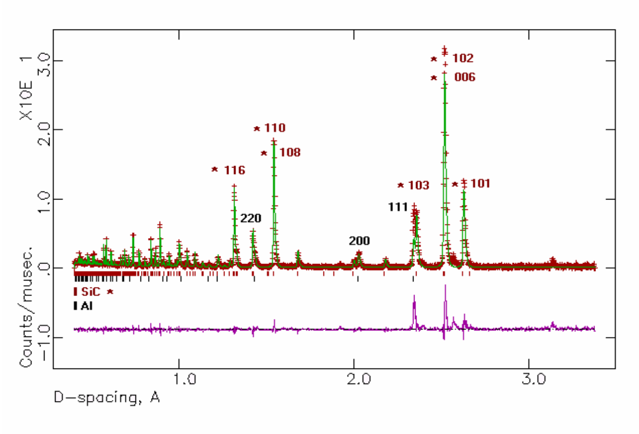


The new strain scanner ENGIN-X, being built at ISIS by the Open University, Imperial College, Salford and Manchester University.

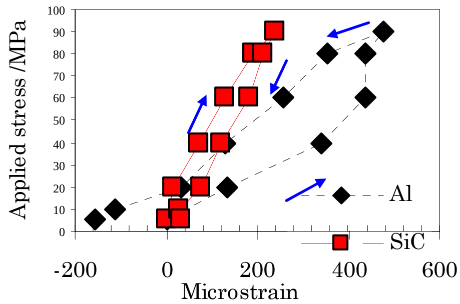
Phase Sensitivity

Because diffraction is phase selective, it is possible to use neutron diffraction to provide information about the performance of individual phases in multiphase and composite materials. In one project neutron diffraction is being used to assess the role of cementite in high (and low) carbon containing steels during deformation (below).

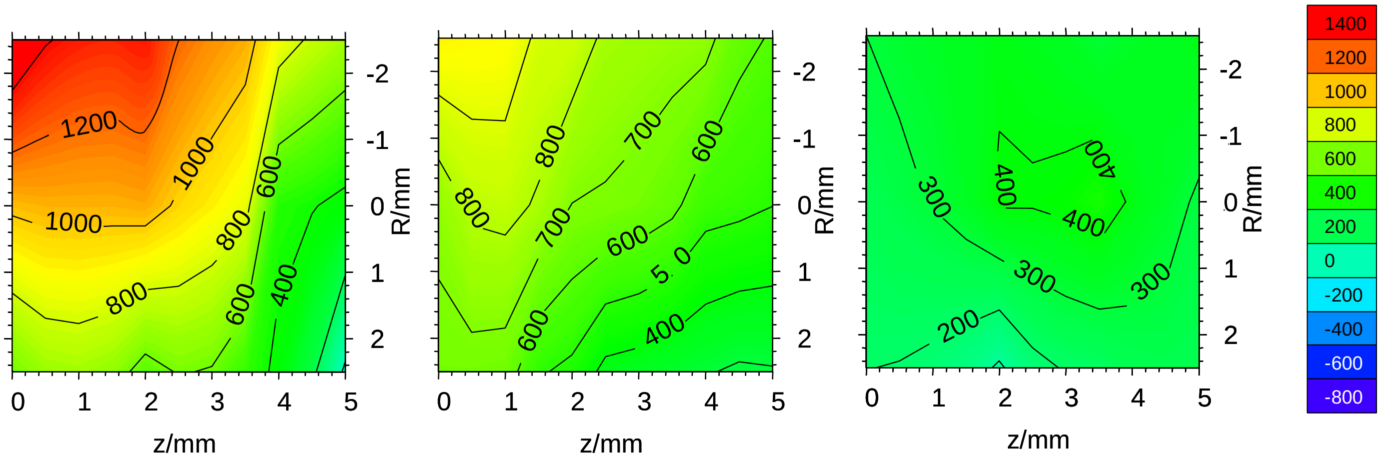
Case Study (1) - Lattice Strain in Al/SiC Composite



Typical diffraction profile obtained from a Al/SiC composite at ISIS. The data is fitted using Rietvield refinement. The difference between the diffraction data and the fit is also shown below the profile.

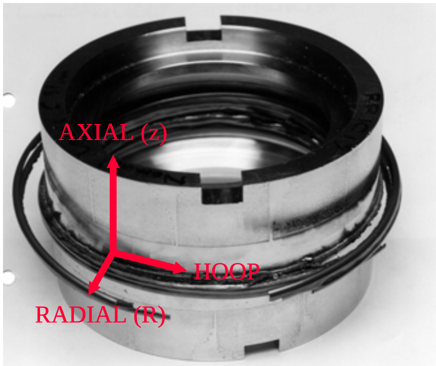


Internal strains measured in the reinforcement and matrix during a loading unloading cycle in the composite in its as received state.



Case Study (2)-Residual Stresses in Inertia Welds

Contour plots (above) of the hoop stress fields in a large inertia friction weld measured in the as-welded, conventional and modified PWHT condition of a nickel based superalloy. Large residual tensile stresses are observed at the weld line (z = 0 mm) and close to the inner diameter of the tubular weld (R = -2.5) in the as-welded condition. After conventional PWHT, the tensile stresses still reach non-acceptable 900 MPa, Increasing the temperature of the PWHT by 50°C reduces the tensile stresses sufficiently below 500 MPa. This work also demonstrates the importance of studying different aspects in friction welds. When residual stresses demand a modification of the PWHT, it is also important to understand the impact of an increased temperature during PWHT on the microstructure and mechanical properties of the component.



A picture of the nickel inertia weld and the definition of the coordinate system.

FaME-38

FaME38 is a new Facility for Materials Engineering that has been set up jointly by ILL/ESRF. The principal objective of FaME38 is to deliver, in close collaboration with beamline staff, the extra facilities and support that engineers need.

FaME38 will provide engineering users with a "Technical Centre" equipped with a co-ordinate measuring machine to determine complex and distorted component shapes, together with facilities to simulate and optimise scans off-line before starting measurements on-line. The materials laboratory will have micro-structural characterisation and static and dynamic thermo-mechanical loading equipment. The "Knowledge and Training Centre" will provide technical and scientific know-how. Users will be helped to draft proposals, to plan and prepare experiments off-line, and be assisted with data collection, on-line processing and analysis. For more information contact: Fame38@esrf.fr .

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