Steacie Institute for Molecular Sciences

Neutron Program for Materials Research

Non-destructive Stress Mapping

Product Development

Process Evaluation

Failure Analysis

Residual Stress

Non-destructive

NEUTRON FACT SHEET #2

Completely non-destructive and highly accurate: neutron diffraction is used to determine internal residual stresses in crystalline materials (e.g. metals, alloys, ceramics and composites). Neutrons can probe several centimeters beneath the surface—well into joints, internal components and other critical sub-surface regions vital to the performance of materials and engineering components. The spatial resolution (defined by a volume element) ranges from 0.2 to 1,000 mm^3.

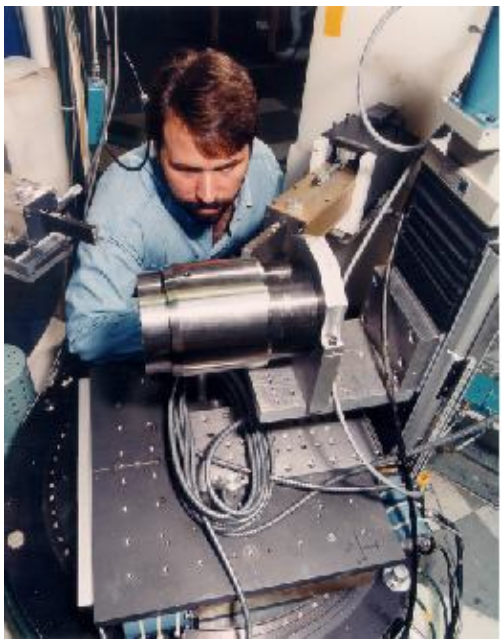

Figure 1: Determining the thermal evolution of stress in a 3-component (Inconel, Zr-2.5%Nb, & Stainless Steel) rolled joint.

The resolution in lattice strain is of the order 0.01%.

New Product Development

Information on residual stresses at the design stage can help to optimize the performance and reliability of new products. Prototypes can be evaluated and compared against calculations.

Process Evaluation

Knowledge of the development of residual stress in components at various stages of production—extrusion, rolling, machining, welding and heat-treating— can be used to optimize processes and improve product reliability and performance.

Problem Solving

Residual stress data can help in determining the causes of failures so that appropriate remedial action can be taken. With neutron diffraction, accurate measurements can be obtained deep within a joint or below highly corroded or fouled surfaces. Neutrons penetrate right through the surface region, no surface preparation is needed.

NRC·CNRC

Aircraft Components

Steel Forgings

Weldments

Pipe Steels

Rail Steels

Ceramics

Composites

Turbine Blades

Pressure Vessels

Reactor Components

Heat-exchanger

The Technique

When an incident neutron beam strikes a specimen it is diffracted at an angle that depends on the distance between the planes of atoms. This angle is measured with a neutron diffractometer and the distance calculated.

The technique requires an intense neutron source and precise alignment of the neutron beam. At Chalk River, neutrons are provided by the high-flux NRU research reactor.

Measurement locations are defined by precise, computer-controlled specimen translations and rotations. Specimens can range in size from a few grams to 500 kg.

Applications

The depth to which neutrons will penetrate depends on the type of material, but is approximately 30 mm in steel and 300 mm in aluminum. This allows the technique to be applied to a wide range of important engineering materials and full-scale critical components.

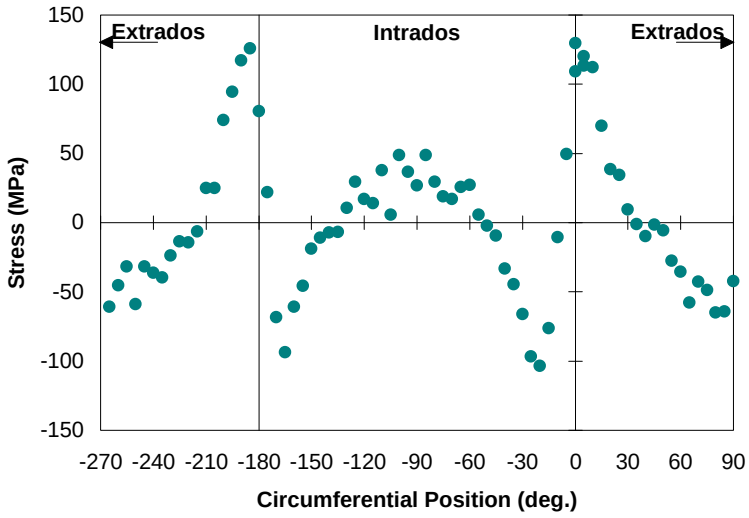

Figure 2: Residual stress variation (in MPa) measured around the circumference of a bent tube. The nominal flank position is at 0°.

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