Australian Centre for Neutron Scattering (ACNS)

Kowari

Residual Stress and Diffractometer

Kowari is a residual stress diffractometer which can be used for 'strain scanning' of large engineering components as large as one ton. The integrity of engineering components often depends on strains and stresses inside the material. For example, rails can fail if stresses exceed the 'ultimate tensile stress'

Neutron diffraction

A neutron beam is scattered within a crystalline material creating diffraction patterns to determine the arrangement of atoms within the material. By examining the spacing of the atomic planes residual strains can be determined.

What makes Kowari special?

Neutron strain scanning is a non-destructive method applicable to nearly all crystalline materials which provides sub-surface information not obtainable by any other technique. It can determine important mechanical properties, to validate finite element models, which predict mechanical behaviour for increased reliable performance or lifetime predictions. It is also used to compare experimentally determined stresses with critical material characteristics.

Applications

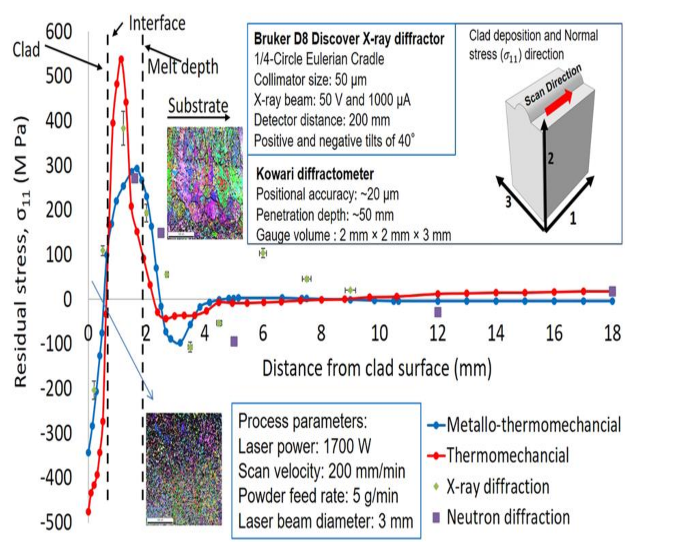
The residual stress diffractometer can be used to reveal:

- Residual stresses in welds such as rails, pipelines, airplanes
- Stresses in coatings such as thermal barrier, wear resistant and corrosion resistant coatings
- Stress corrosion cracking due to extreme environments such as:
  - –Heat + pressure (pressure pipes of power generators)
  - –Corrosive environment + stress (pipelines, steel reinforcement in concrete)
- Fatigue, crack growth and development in materials undergoing contact stress, structural components and load-bearing parts.

CASE STUDIES

Neutrons for additive manufacturing

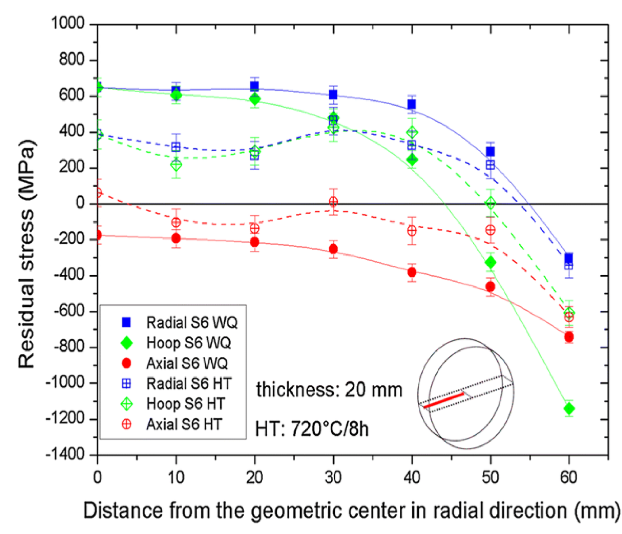
Laser material deposition based restoration of high-value components can be a revolutionary technology in remanufacturing. The deposition process induces residual stresses due to thermomechanical behaviour and metallurgical transformations. The presence of tensile residual stresses in the deposited layer will compromise the fatigue life of the restored component. We have developed a fully coupled metallurgical, thermal and mechanical model to predict residual stresses. We have validated the model using neutron and micro-focus X-ray diffraction measurements.



Critical deposition height for sustainable restoration via laser additive manufacturing, Paul et. Al., Nature Scientific Reports 8, Article number: 14726 (2018)

Neutrons for Aerospace

We used neutrons to follow evolution of residual stress during aging in nickel-base superalloy for the first time by a combination of in-situ & ex-situ measurements. Superalloys are often used in manufacturing of disks & blades for the hot section of aero engines. Usually conventionally aged in order to develop a favourable microstructure & to relieve stresses. The measurements were carried out on 3 different strain scanners, demonstrating versatility of developed heating setup & feasibility of such experiments on different diffractometers.



In-Situ Study of the Stress Relaxation During Aging of Nickel-Base Superalloy Forgings, Aba-Perea et. Al., Metallurgical & Materials Transactions A 2019

SPECIFICATIONS

Kowari is located on the thermal neutron guide TG3

Neutron beam:

·Maxwellian distribution with peak intensity at ~1.5 Å
·Wavelength range: 1.20-2.85 Å
·Take-off angle range: 55-165°
·Max beam size: 60x30 mm^2

Monochromator::

·Double focusing bent perfect crystal
·Si(400) cut with [110] vertically
·Monochromator is made from 9 packets each composed from 13 wafers.
·Wafer dimensions: 270x17x0.91
·Work area: 200x170 mm^2
·Thickness: 11.6 mm
·Available reflections (004), (111), (311), (511)

Detector:

·DENEX 2D, 3He-filled,
·Total area 300x300 mm^2
·Detector coverage: 15°x15° (@ LSD ~ 1000 mm)
·Angular range: 40°< 2θB < 120°

Sample table:

·Unique telescopic design
·Maximum sample weight ≤ 1 tonne
·±250 mm travel for X and Y
·600 mm travel for Z

Instrument performance:

·Flux at sample position $7x10^6$ n cm^2s^{-1} (depends on monochromator reflection and focusing).
·Instrument is optimized for d-spacings ~ 1.1-1.3 Å at ~90°.
·These are the most important reflections in engineering applications αFe(211), γFe(311), Al(311).
·For this range resolution is Δd/d ~2 x 10-3

INSTRUMENT SCIENTISTS

Dr Vladimir Luzin
EMAIL vladimir.luzin@ansto.gov.au
PHONE +61 2 9717 7262

Dr Mark Reid
EMAIL mark.reid@ansto.gov.au
PHONE +61 2 9717 7006

Dr Floriana Salvemini
EMAIL filomens@ansto.gov.au
PHONE +61 2 9717 7591