

Validating repair solutions for the aerospace industry

By using neutrons to map the residual strain in aluminium alloys, researchers from Coventry University, supported by Airbus and the US Air Force Research Laboratory, have gained greater understanding of how surface treatment can extend the fatigue lifetime of aerospace structures.

Challenge

Fatigue cracking is a critical issue for the aerospace industry, as components can be highly stressed by repeated loading. Designing damage-tolerant structures with greater longevity requires an understanding of where cracks will initiate and grow, as well as implementing systems to detect cracks before they cause failure.

Laser shock peening (LSP) is a surface treatment used to protect metallic parts against fatigue and improve resistance to wear. The method is widely used for aero-engines but its cost, relative inflexibility in application, and the effort required to optimise it for different materials have limited large-volume commercial applications, including in the aerospace sector.

Solution

A team from Coventry University, supported by Airbus and the US Air Force Research Laboratory, used the IMAT instrument at ISIS Neutron and Muon Source to map the residual strain induced by cold expansion and laser shock peening of aluminium alloy samples.

Benefits

Neutron transmission strain mapping improved researchers' understanding of how commercial LSP technology generates residual stress in aerospace aluminium alloys; how that residual stress can be tailored to slow the growth of fatigue cracks; and how models of the process need to account for cyclic hardening properties of the material peened. The research has informed the application of LSP as a manufacturing tool, as well as for repairs where fatigue hotspots are identified in-service, or to arrest growing cracks.

In demonstrating the safe implementation of LSP, the research has reduced the cost of developing new repair solutions to the US Air Force, and enabled the commissioning of a bespoke system for airframe repair by Airbus.

“The adoption of laser shock peening has allowed the aerospace industry to safely extend the life of aircraft parts by identifying how cracks form and grow in response to mechanical stress. Key to this is understanding how laser shock peening generates residual stress in aluminium alloys, and how this can be tailored to slow the growth of fatigue cracks. Using neutron diffraction and imaging at ISIS gave unique insights into the internal stresses with high resolution, contributing to our overall understanding and allowing development of accurate models for life prediction and assurance of structural integrity.”

Professor Mike Fitzpatrick, Coventry University



Why use neutrons?



Study structure

Neutron wavelengths are comparable to the spacings of atoms and molecules.



Study dynamics

Neutron energies are comparable to the time scales of molecular diffusion, vibrations and rotations.



Study magnetism

The neutron's magnetic moment can be used to study the microscopic magnetic properties of materials.



Penetration power

Neutrons can penetrate deep into matter (including many different metals) enabling the study of large samples – even within complex sample environments.



Non-destructive

As a non-destructive, non-invasive probe, neutrons are suitable for the characterisation of delicate and precious samples.



Versatile sample environments

Sophisticated sample environments enable measurements under operating conditions – including extreme temperatures and pressures.



Sensitivity to light elements

The neutron scattering power of nuclei varies in a random manner such that lighter atoms (e.g. H, Li) can be studied in the presence of heavier ones.



Isotopic contrast

Neutrons are sensitive to different isotopes of the same element, so isotopic substitution (e.g. H/D) can be used to highlight specific structural features.



Complementarity

Neutron scattering is highly complementary to other techniques, such as X-ray scattering, electron microscopy, magnetic resonance and computational methods.

How to work with ISIS

ISIS offers industrial users access to advanced analytical techniques and expert scientific and technical support for materials characterisation. Access options include proprietary use, academic partnerships, grant funded access, and the Industrial Collaborative Research and Development (ICRD) program.

For more information, email ISISindustry@stfc.ac.uk to discuss the most suitable method to solve your challenge.

