Science and Technology Facilities Council

Understanding stress to extend the lifetime of jet engines

Rolls-Royce have returned to the Engin-X instrument at ISIS to measure the residual stress in jet engine parts to understand how it impacts their lifetime.

Challenge

During the manufacturing process of jet engines, parts are joined using inert friction welding. This process introduces residual stress into the component, which strongly impacts how long they can safely operate under the high temperature and high stress conditions of an engine.

At Rolls-Royce, predicting how long a part will last before failing is done using a combination of monitoring measurements and computer modelling. This enables them to make a judgement on when a component needs to be replaced, which is often very conservative. By understanding where on a component the measurement should be taken to dictate if it should be replaced, they can potentially extend its lifetime, reducing maintenance periods and overall environmental impact. The stresses in the components vary around their circumference, and it is important for the company to understand these variations.

Solution

Rolls-Royce came to Engin-X to characterise the stresses in the bulk of components where X-rays cannot reach. This is because neutrons can penetrate further into materials that strongly absorb X-rays. By combining X-ray and neutron techniques with hole-drill measurements, they can build a full picture of the stresses inside a component.

Benefits

Their results will enable Rolls-Royce to validate their models so they can predict what happens to the materials during the welding process. This will allow them to expedite the development of the manufacturing process without having to do destructive measurements on each part, or leave measurements until the end, which comes with more risk. They are not as reliant on surface level hole-drill measurements as they have a better understanding of the stresses deeper in the component.

> **"The Engin-X beamline scientists have a good relationship with industry and make it easy to do experiments. The experience of working with the beamline scientists is why we keep coming back to ISIS for various projects over the last couple of decades. The ICRD industrial access program is good for engaging with industry and makes it very easy to work with ISIS to do the measurements."**
>
> Andrew Barrow, Rolls-Royce

Science and Technology Facilities Council

ISIS Neutron and Muon Source

ISIS Neutron and Muon Source has successful collaborations with many different industries, delivering insights to develop new and improved materials and processes.

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.