Science and Technology Facilities Council

Testing a cheaper, quicker method of making spacecraft components

Researchers from European Space Agency (ESA) and their commercial partners used neutron diffraction to test a new method of manufacturing propellant tanks for spacecraft.

Challenge

Friction Stir Welding (FSW) is a versatile, energy efficient and environmentally friendly solid-state joining technique that has been used for building high-strength aluminium-based aerospace components. Although FSW produces high-quality welds, residual stresses can be present after any manufacturing process and can cause distortion and degrade mechanical performance, which can lead to component failure. It is therefore critical to understand the residual stresses that are present once parts have been joined together.

Previous studies have investigated residual stress inside flat FSW components. Together with TWI Ltd. and Airbus UK, researchers from ESA wanted to study residual stresses in curved components for the first time using a prototype spacecraft propellant tank.

Solution

Neutron diffraction at ISIS Neutron and Muon Source was used to study residual stresses within the bulk of the tank, exploiting the highly penetrating but non-destructive nature of neutrons. Alongside this, X-ray diffraction and hole drilling were used to study the surface of the propellant tank. Neutron diffraction at ISIS Neutron and Muon Source was used to study residual stresses within the bulk of the tank, exploiting the highly penetrating but non-destructive nature of neutrons. Alongside this, X-ray diffraction and hole drilling were used to study the surface of the propellant tank.

Benefits

Combining the results of neutron and X-ray diffraction and hole drilling, the team were able to determine the magnitude of the residual stresses near the joint around the tank circumference and evaluate these in the context of the requirements defined by the space industry.

The measurements showed that the residual stresses in the joints of FSW components were lower than the stresses in tanks fabricated using electron beam welding. This confirmed that the new method for joining hemispherical and cylinder structures meets the stringent criteria of the space industry with regards to residual stresses in the weld.

> **"We had a new technology and were facing a challenging research problem with the structural integrity of these propellant tanks. The scientists and experts at ENGIN-X did an outstanding job and helped us design the experiment and evaluate the data. We are certainly hoping for future collaborations on similar topics."**
>
> Martina Meisnar, Materials And Processes Engineer, ESA

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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.