Using neutrons to investigate stress in aircraft components

Science & Technology Facilities Council

STFC's Harwell Imaging Partnership (HIP) has aided Rolls-Royce in evaluating the benefits of fillet rolling on stress in aircraft engine components, by enabling access to STFC's ISIS neutron and muon facility, as well as to new data analysis software created by STFC's Scientific Computing Department.

The challenge

Rolls-Royce plc is the second largest manufacturer of aircraft engines in the world. With over 13,000 engines in service across the globe, the requirement for performance is greater than ever. Currently the company is investigating the viability of making aero engine bolts from ATI 718Plus® superalloy. To handle the demanding service conditions of an aircraft engine, it is crucial that these bolts offer good fatigue strength in areas of high stress concentration such as the bolt head fillet and the thread.

The solution

Through collaboration with STFC, Rolls-Royce was able to access the Engine-X facility at ISIS. By inducing compressive residual stress through fillet rolling and thread rolling processes and then bombarding samples of ATI 718Plus® with a stream of neutrons; it was possible to conclude which method of manufacture was the most effective at producing bolts with the greatest fatigue resistance. Analysis software created by STFC's Scientific Computing Department aided the experiment by streamlining the process of evaluating experimental data. This allowed the construction of radial, axial and hoop residual strain maps which displayed pictorially where strain was most highly concentrated. By comparing the strain maps produced for bolts manufactured in different heat treatment conditions, it was concluded heating the bolt prior to the fillet rolling process maximised the bolt's resistance to residual stress.

The benefits

Working with STFC's ISIS facility enabled Rolls-Royce to collect data that could not be obtained using the conventional hole drilling or X-ray Diffraction methods. The project provided the opportunity to work with collaborative partners such as STFC's computational scientists, who through the use of their analysis software, have helped speed up what has previously been a very long and complicated process. This has resulted in increased efficiency in the evaluation of experimental data and has also enabled Rolls-Royce to determine the benefits of fillet rolling more quickly.

The project has provided evidence verifying the benefits of fillet rolling with bolts made from ATI 718Plus®; something that has been very difficult to demonstrate thus far due to the complexity of producing data that can quantitatively describe a bolt's residual stress profile. As a result Rolls-Royce have achieved a better understanding of the impact of residual stress on bolt performance, which will lead to improvements in the bolt manufacturing process.

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