AFRC
ADVANCED FORMING RESEARCH CENTRE
UNIVERSITY OF STRATHCLYDE

University of Strathclyde Glasgow

Rolls-Royce

Rolls-Royce collaborates on residual stress research to further understanding of aerofoil manufacturing

Background

Residual stress describes the stresses that are locked into a particular material or component as a direct result of manufacturing or fabrication processes. The resulting effects of such stress can have both positive and negative effects on the life and durability of a component after production.

Customer challenge

Rolls-Royce routinely employs residual stress measurement techniques in order to validate the integrity of critical rotating components.

Conventional dimensional measurement techniques, such as the coordinate measuring machine (CMM) capture observable component features, while residual stress measurements provide insight into the underlying material stress-state.

Looking to develop its residual stress capabilities even further, Rolls-Royce approached the AFRC to help it identify the nature of residual stress within a forged and fully processed aerofoil.

"This project enhanced our understanding of the benefits of applying modern residual stress techniques to our established forging processes and the results so far have stimulated important additional work. We will continue to collaborate with the AFRC, further validating these techniques with a view to expanding their application within compressor aerofoil manufacture and strengthening our manufacturing process and product knowledge."

Dr Andrew Russell CEng FIMMM, Staff Technologist

Rolls-Royce

What the AFRC did

Our materials team are globally recognised specialists in the evaluation, understanding and control of residual stress generated as a result of manufacturing processes. They helped Rolls-Royce undertake a study of the residual stresses associated with the manufacture of forged compressor aerofoils.

Measurement techniques used included X-Ray Diffraction (XRD) for surface measurement and Electronic Speckle Pattern Interferometry (ESPI) with hole drilling for sub surface measurement.

Combining ESPI with hole drilling provides a modern and innovative take on the classic hole drilling method. An optical system that measures stress using interference patterns, ESPI eliminates the need for a strain gauge, which requires surface preparation on the component and can hamper measurements.

Using both XRD and ESPI with hole drilling allowed comprehensive mapping of the residual stresses from the surface of the aerofoil down to ~1mm depth. The results helped confirm the nature of residual stress that remains within a forged and fully processed aerofoil.

Business impact

Rolls-Royce has enhanced its understanding of current aerofoil compressor manufacture and demonstrated the strengths and capabilities of two complementary residual stress measurement techniques.

The knowledge secured through this project has been incorporated into further residual stress measurement activities across other Rolls-Royce component families. The residual stress measurement techniques have proven to be a worthwhile addition to the conventional manufacturing engineering toolkit.

This Compressor Blade Residual Stress Mapping research project was a finalist at the 2018 Collaborate to Innovate Awards, which showcases the best in UK collaborative engineering projects.

"...The results helped confirm the nature of residual stress that remains within a forged and fully processed aerofoil."