AMRC advances its residual stress measurement capability

Researchers at the University of Sheffield Advanced Manufacturing Research Centre with Boeing have matured their capability for measuring residual stresses in high-value manufactured aerospace components.

Residual stresses can be produced and affected by a range of manufacturing processes, including heat treatment, machining, and surface treatments such as shot peening. The fatigue life of a component has a direct correlation to the residual stresses that it inherits during the entire manufacturing process, therefore understanding the evolution and interaction of residual stresses during the whole manufacturing chain is of utmost importance.

At the AMRC, measurement of the residual stresses helps our engineers to understand the overall surface integrity and the service life of components when newer, faster and more advanced manufacturing techniques are being developed. Key conventional techniques for measuring residual stresses include hole-drilling – a destructive technique that involves the use of strain gauges for measuring changes in surface strains due to relaxation of residual stresses as the hole is drilled to a range of depths. Recently, the AMRC's Residual Stress Measurement Group (RSMG) has matured its capability to use X-Ray Diffraction (XRD), a non-destructive to semi-destructive technique to measure residual stresses within the component.

XRD can provide more accurate results than hole-drilling, with better resolution for surface and near surface measurements up to a depth of around 100 – 200 µm. This is critical for understanding the machining effects on the surface and subsurface of the component. The technique can be used to measure surface residual stresses – up to 10 µm deep – non-destructively. This means it could be used on components like aero engine fan blades, which are then put into service and can be retested at regular intervals during their service life. When it comes to measuring the near surface and subsurface residual stress, some of the material has to be removed by electro polishing, which leaves a dimple in the surface.

Developing and maturing the XRD capability within the AMRC has taken about a year and required several challenges to be met, says Krunal Rana, project engineer with the AMRC Process Technology Group's Residual Stress Measurement Group. Although the technique uses a weak x-ray source, it was still important to ensure that the staff using the technique had the appropriate health and safety training and that others working on the shop-floor were reassured about the absence of any potential risks. The next challenge was to develop the skills to carry out electropolishing to guaranteed, repeatable standards within the AMRC. Having overcome those hurdles, Krunal Rana and technician Steven Tyas have completed a series of studies on different materials ranging from steels to superalloys, processed using different manufacturing techniques, to prove the AMRC's XRD measurement capability.

They have also taken part in 'Round Robin' tests, involving research centres in Singapore, Germany and the UK, designed to demonstrate the robust and stable nature of each centre's measuring capabilities.

For more information on the AMRC's residual stress measurement capabilities, contact:

Krunal Rana MSc (Hons), CEng MIMechE Tel: (+44) (0)114 222 6679 E-mail: k.rana@amrc.co.uk