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A study of residual stresses and their effect on thermo mechanical fatigue in complex geometries

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It is known that residual stresses within engine components, such as turbine housings, can combine with service generated stresses and cause unexpected failures during operation, therefore it is important that all the stresses (residual and induced, compressive and tensile) are fully characterised and understood.

The use of neutrons as a tool to measure the strains within a material is well established; however, applying this technique to complex engineering components can prove challenging. This research investigates the measurement of residual stresses in complex geometries found within the turbine housing component of a turbocharger using neutron diffraction. The effect of various production methods on residual stress distributions is also explored.

Successful strain measurements were taken using the Engin-X instrument at the ISIS spallation source from three turbine housings selected from various stages in the manufacturing process, allowing a study of the effect of heat treatment and machining on stress magnitudes and direction. The turbine housing consists of various sections greater than the maximum 60mm path length of the neutrons, therefore path lengths must be carefully chosen to achieve acceptable neutron count rates. Engin-X benefits from an automated experimental setup to make the selection of this limited path length easier on complex shapes. The turbine housings were mounted on to a positioning table allowing translation in X, Y, Z directions and also rotation in , . Each of the housings were scanned using laser scanners and this in conjunction with the virtual path length measurement software SScanSS allowed automated measurements of acceptable path lengths to be made. On this occasion measurements in one principal direction were measured and the correct measurement methodology established.

Continuation of this work was then carried out on SALSA at the ILL reactor source. Measurements were made on turbine housings, one as cast and one heat treated. The internal divider wall of each turbine housing was examined as this is an area where crack initiation can occur. The results showed that, heat treatment can reduce compressive residual stresses. However, compressive stresses are thought to slow the onset of crack initiation and could be beneficial in the material, this will be investigated further in future work.

It is hoped that this information will be used to improve production methods and result in improved simulation methodologies to allow accurate predictions of thermal fatigue and fracture locations to be established.

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