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Residual stress analyses using diffraction techniques

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Residual stress is a double-edged sword since tensile stresses, especially when existing close to surfaces, can lead to component failure due to stress corrosion cracking, whilst compressive stresses mitigate against crack formation and propagation. Diffraction techniques enable analyses of the prevailing residual stress conditions from direct investigation of the lattice plane spacing. By combining this property with penetrating radiation such as hard X-rays and thermal neutrons, depth-resolved information can be obtained.

Using hard X-rays (energies larger than 65 keV) produced in synchrotron facilities has made possible the elucidation and quantification of depth influences resulting from:

- Surface stress modification treatments such as shot peening to enhance fatigue lifetimes in steel samples;
- WC-Co hard metal coatings on substrates that rendered extensive differences in the coefficient of thermal expansion between such coating and the substrates. This leads to interactive thermal stresses that may be beneficial to both the coating and the substrate.

Notwithstanding the capability of depth profiling to typically 50 μm resolution, data quality is strongly influenced by grain statistics. With neutron diffraction investigations larger gauge volumes need to be employed that largely mitigates the latter effects.

We shall report on the complementary use of X-ray and neutron strain analyses towards depth-resolved investigations of these systems.

References:

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