Plastic Strain Mapping by Peak Broadening Analysis in Titanium

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X ray diffraction measurements in bulk engineering component traditionally concentrate on the evaluation of lattice spacing variation by application of Bragg law. By comparison with strain free specimen reference, elastic strains are computed and hence local stress is inferred. This methodology primarily concentrates on the diffraction peak centre position, neglecting the wealth of information about the local material state contained in the shape of the measure diffraction peaks.

It has been shown that diffraction peak width is closely linked to local dislocation density, which in turn gives hints to the plastic strain a particular material volume has experienced. Thus by correlating peak width and corresponding plastic strain in a given material, it should be possible to determine plastic strain distribution and magnitude in a specimen for which a map of diffraction patterns has been collected.

To test this hypothesis a plate specimen with two circular notches was loaded in tension to achieve a known plastic strain distribution localised around the notches. Mapping of the central region with X-ray in energy dispersive mode was carried out on beamline 16.3 at SRS in Daresbury, England. The measured residual elastic strains show good agreement with a finite element model of the geometry. Single peak widths for the entire gauge area were computed, combined in a number of ways and then plotted in the gauge area. These maps show good agreement in terms of the extent of significantly broadened peaks with the numerically predicted zone of most prominent plastic deformation, confirming that peak broadening does indeed give important clues to the spatial distribution of plastic deformation.