Diffraction Geometry and the Determination of Strain Free Lattice Parameters for Residual Stress Measurements

J M Shackleton , Prof. PJ Withers, Dr M Preuss
Materials Science Centre, School of Materials, Grosvenor Street,
Manchester, M1 7HS

In the last 10 years, neutron and synchrotron x-ray diffraction has become an important tool to characterise residual stresses in engineering components. The residual stress is calculated from measurements of strain. As strain is the change in the lattice parameter a starting point is needed. The perennial problem is the measurement of this strain free lattice parameter. Strain free samples can be prepared and far-field measurements can be made. However, these may not be representative of the materials being measured. Specimens and components measured at large scale facilities are often of complex geometry and have undergone phase transformation during processing. As cooling rates during processing will have varied across the components – here welds are an extreme example – the chemistry of the phase contributing to the diffraction signal used for the stress characterisation is likely to vary within the component. Consequently, the strain free lattice parameter cannot assumed to be constant throughout the volume that is characterised for residual stresses.

It has been demonstrated in the past that the $\sin^2\psi$ method, using laboratory X-rays, can be applied to determine the strain free lattice parameters. However, little is presently known about the accuracy of such measurements and what type of instrumentation is favourable. This paper will explore various effects of diffraction geometry on this critical measurement. Parameters such as slight sample misalignment, the effect of parallel optics versus focussed optics will be explored. The possibility of measuring strain free lattice parameters with a portable instrument will also be explored as such instruments are flexible, easy to use and they can measure very large samples.