APPLICABILITY OF THE SIN^2(Ψ) TILT METHOD IN NEUTRON STRAIN MAPPING

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The carburization of many steel parts, such as gears, presents a complexity for neutron strain mapping as the conventional method requires that the lattice spacing in the strain-free condition (d_0) be known at each location within the sample. However, residual stresses at the surface of carburized steel components are often measured using x-ray diffraction methods that utilize the $\sin^2(\psi)$ method. This method assumes that the stress normal to the surface is zero, and when this condition exists the need for d_0 is eliminated. With the depth of penetration of x-rays being limited to a few microns, the plane stress condition is frequently met. With x-rays, depth profiling can be accomplished using electro polishing to remove layers and repeating the x-ray stress measurements. Yet, due to the time required for electro polishing and the need for correction to the derived stresses due to the layer removal, the effective depth of stress mapping by x-rays is limited.

The low attenuation and consequential deeper penetration of neutrons is widely used for non-destructive measurement of stress within the bulk of components. Typically, the neutron stress measurement depth extends from tenths of a millimeter to several centimeters. In the neutron diffraction method the changes in d-spacing between stressed and unstressed states leads to the determination of strains and consequently the stresses as a function of location. Determination of d_0 as a function of depth, however, is required when chemical gradients exist. However, obtaining d_0 at each location when chemical gradients exist can be a significant challenge for the neutron diffraction method.

This paper presents the effort to assess the potential of applying the $\sin^2(\psi)$ method to neutron strain mapping in order to measure d_0 as a function of depth when the plane stress condition exists. Measurements of the d-spacing as a function of tilt angle and depth were made using the second generation Neutron Residual Stress Mapping Facility (NRSF2) at HFIR. Corrections for settings where the gage volume was partially buried in the sample were made based on measurements from an iron powder sample packed into a flat surface sample holder. Assuming the plane stress condition is valid and applying corrections for partial burial of the gage volume then one can calculate the in-plane stresses and the d_0 at each depth. Efforts to apply a neutron diffraction based $\sin^2(\psi)$ method to measuring the total stress in an un ground carburized spur gear will be presented.

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