Nondestructive measurement of near-surface residual stress levels versus depth in an induction-hardened sample and a shot-peened sample

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The lifetime of steel parts experiencing cyclic fatigue is directly influenced by the residual stresses present. Here, two steel samples with similar chemical compositions were prepared: 1) a forged, induction-hardened and ground component, and 2) a forged and shot-peened component. The processing of these samples produces steep residual stress gradients as a function of depth near the surface region, which has proved essential in producing the desired cyclic fatigue durability. Such residual stress gradients in steel components have typically been measured using a destructive etch/layer removal method as outlined in SAE J784a [1]. Unfortunately, the problem with this method is the loss on the contractive strain component as the layers are removed and the effect on the remaining lattice. While the SAE standard is intended to compensate for some of this loss, a nondestructive method is often desirable.

Synchrotrons offer a high-flux, monochromatic, high- and variable-energy radiation not available during the development of this engineering standard. By varying the energy of the incident radiation used, the depth of penetration of the x-ray beam is altered. The measurement of a single location at various wavelengths can provide a non-destructive measure of the residual stress gradient as a function of depth. $\sin^2\psi$ measurements [2] were made on the aforementioned samples at energies of 31 and 40 keV at the UNI-CAT 33-ID beamline. These measurements will be combined with data from National Synchrotron Light Source, and laboratory sources will provide a nondestructive residual stress profile that will be compared to measurements using the conventional etch/layer removal method for the same samples. Data analysis is still underway and is part of RDE's Master of Science thesis [3] at the University of Cincinnati.

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References

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