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Residual stress measurement to test vehicle components

Residual stresses—internal stresses in materials resulting from manufacturing processes and from operation on the road—can develop in materials used in gasoline and diesel engines. These stresses eventually lead to degraded mechanical performance, corrosion cracking, and shorter lifetimes and sometimes catastrophic failure.

ORNL's Residual Stress User Center, a joint effort of the High Temperature Materials Laboratory and the Neutron Sciences Directorate, conducts nondestructive testing of engine components using neutron and x-ray diffraction techniques. These techniques help industry partners identify manufacturing processes that minimize the generation of residual stresses, test whether a part can tolerate demanding applications, and see whether heat treatment (e.g., annealing) can eliminate or reduce residual stresses in a component. Developers of computer models can incorporate data from these studies to predict more accurately when residual stresses combined with external stresses will cause deterioration and failure. Researchers from Honeywell Turbo Technologies used neutron and x-ray diffraction instruments available through the Center to measure residual stresses in shaft wheel assembly (SWA) weld joints from vehicle turbochargers produced under different conditions.

Technology Achievements

- Residual stress measurement—The Neutron Residual Stress Facility at ORNL's High Flux Isotope Reactor was used to map residual strains in the region near the electron beam weld joining the shaft to the turbine wheel using neutron diffraction techniques. Strains were measured in both the through-thickness and circumferential directions in an as-welded sample and another annealed at 1100°C. The results showed changes in tangential and radial strains around the circumference localized within a 30° angular range.
- Quantification of defect density—The PROTO IXRD x-ray diffraction instrument was used to measure near-surface stresses and peak breadth along the length of the shaft in two bearing regions. SWAs in three conditions were examined: as-welded, standard stress-relieved, and annealed at 1100°C.
- Analysis of the x-ray diffraction data confirmed neutron scattering results showing that annealing removed residual stresses created by welding.

Key Accomplishments

- Honeywell Turbo Technologies used neutron and x-ray diffraction to measure and map residual stresses in the SWA weld joints of vehicle turbochargers. The data showed that the standard manufacturing process was not fully effective in relieving stresses arising from electron beam welding but that annealing at 1100°C relieved effectively all residual stresses. The findings will help Honeywell design SWAs of the highest quality and monitor its manufacturing processes.
- Other collaborations with Honeywell have been planned to evaluate cost-effective ways of mitigating residual stress to extend component life and ensure the reliability of the SWA and the turbine housing in the company's turbochargers.

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