Neutron Diffraction
Determining Stresses in Materials
Argonne National Laboratory, Illinois

With a unique combination of analysis and research instruments developed at Argonne National Laboratory, scientists can use Argonne's Intense Pulsed Neutron Source (IPNS) to interrogate materials that make up ceramic engine parts, nuclear reactor components, and advanced jet engines and make predictions about their quality and life expectancy.

Large residual stresses can develop in composites during fabrication. Determination of these stresses is crucial for predicting composite performance. By learning how cooling, heating, and processing affect residual stress, stronger, tougher composites can be developed. The only effective, nondestructive way to measure internal residual stress in composites is with neutron diffraction. Neutrons penetrate materials and permit bulk measurement of strain, whereas x-rays measure only surface stresses.

The research carried out at Argonne using the Intense Pulsed Neutron Source (IPNS), is the only place in the country where this kind of research on composites can be done so efficiently. IPNS is a pulsed source with six detector banks that can provide diffraction data in various spatial directions simultaneously. A number of companies and laboratories are using this data to understand the processing of composites and to validate computer models that predict mechanical properties. The result could be better processes that make stronger, tougher, and lighter composites.

Argonne tests critical materials, such as advanced ceramic and metal composites, high-temperature superconducting materials, and nuclear reactor component mock-ups for industry. The information supplied to industry is used to modify product design. This work is conducted by a research team of physicists, mechanical engineers, ceramists, and instrument scientists from three Argonne divisions using information from IPNS.

Neutron diffraction offers the unique capability of providing bulk measurements, with neutron penetrations of up to many millimeters. If both macrostresses (from welding or surface finish) and microstresses (those on the scale of the microstructure) are present, the macrostresses are averaged out within the sampling volume, thus...
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making the microstresses directly accessible. This is a significant advantage over x-ray diffraction, which measures only near-surface stresses that may include macrostresses. Also, observing the way neutrons scatter as they pass through a material provides information about atomic spacing that can be used to calculate residual stress.

The application of neutron diffraction to the determination of stress is a relatively new technique that has been validated at Argonne mainly for composites but also for large components such as turbine rotors, large bearings, and large welds. A considerable effort has been made at Argonne to bring this technology to the industrial sector. At the current time, through the user program, IPNS is available to any industry interested in determining residual, as well as applied stress. The facility is accessible to industry and university users. Components can be studied at IPNS while undergoing changes in temperature, pressure, and atmosphere during measurement. Strain can be measured to a sensitivity of one part in 10,000.

For their pioneering work in applications of neutron diffraction to composites, five Argonne researchers (Dick Hitterman, Dave Kupperman, Saurin Majumdar, Jim Richardson, and J.P. Singh) won a 1992 Federal Laboratory Consortium award for excellence in applying federally funded research to benefit American industry.

Argonne researchers hold a patent on a neutron stress monitor for composites and have won an R&D 100 Award for developing the stress monitoring technique for composites. IPNS is a national user facility. Beam time can be obtained on one of the instruments by having a proposal approved by the oversight committee or by purchasing time from Argonne's IPNS division. If an experiment is assigned time on an IPNS instrument, Argonne staff will be available to assist a company's staff in completing the work. Companies interested in working with this facility are encouraged to mail or fax a letter to the Industrial Technology Development Center, ITD-900, 9700 S. Cass, Argonne, IL 60439 708/252-5230.

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