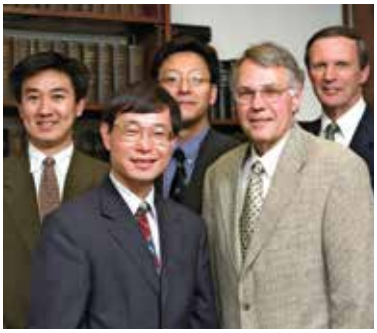
MTS

University of Tennessee and ORNL

CUSTOMER CASE STUDY

Getting Particular

MTS helps the University of Tennessee in its quest to apply state-of-the-art neutron scattering technology to materials science by designing a unique mechanical test system.



"The VULCAN diffractometer stands to significantly advance the materials science body of knowledge . . . the load frame portion of the system is central to its successful use for material characterization. Since the neutron beam is in a fixed position, the load frame and its control system must achieve extreme precision to keep the specimen centered within the beam while applying the specified torque, tension, and compression."

Dr. Peter Liaw (second from left)
Principal project investigator
University of Tennessee

CUSTOMER CHALLENGE

Neutron science provides an exceptional means for studying the structure and dynamics of materials at the atomic level. Oak Ridge National Laboratory is home of the Spallation Neutron Source and the High Flux Isotope Reactor, two world-leading facilities for neutron scattering research. SNS is an accelerator-based neutron source built by a partnership of six U.S. Department of Energy laboratories. The one-of-a-kind SNS facility at Oak Ridge will generate the world's most intense pulsed accelerator-based neutron beams for scientific research and industrial development.

These beams are produced by bombarding a mercury target with energetic protons from a large accelerator complex. The protons excite the mercury nuclei in a process called spallation, releasing neutrons that are formed into beam lines and guided to research instruments. SNS has 18 beam lines which can accommodate up to 24 instrument systems, each expected to benefit several areas of science.

In 2004, the Materials Science and Engineering Department at UT in Knoxville received funding from the NSF-MRI Program to develop an in-situ loading system for the VULCAN diffractometer at the SNS.

Commissioned on June 26, 2009, VULCAN is a world-class engineering diffractometer designed to tackle a broad range of problems in materials science and engineering, such as stress mapping in structural components, in-situ deformation studies under complex loading conditions, transient behaviors during synthesis and processing, and the kinetics of multi-length scale phase transformations. The system comprises a neutron guide, a heavy duty sample table, a multiaxial load frame, and an array of specialized detectors. Major funding for VULCAN comes from Canada Foundation for Innovation, with additional construction funds from DOE Office of Energy Efficiency and Renewable Energy. Dr. Xun-Li Wang is the lead scientist and Amy Black the lead engineer, responsible for the overall design and construction of the instrument.

The NSF-MRI award expands the capabilities of VULCAN by providing a unique load frame to enable sophisticated mechanical tests. While using the load frame to apply loads and moments to a material specimen exposed to the neutron beam, researchers will employ the specialized detectors to observe the change in diffraction patterns from the specimen. From these measurements, researchers can obtain insights of the mechanisms of failure in real time, in situ, in three dimensions and at the atomic level.

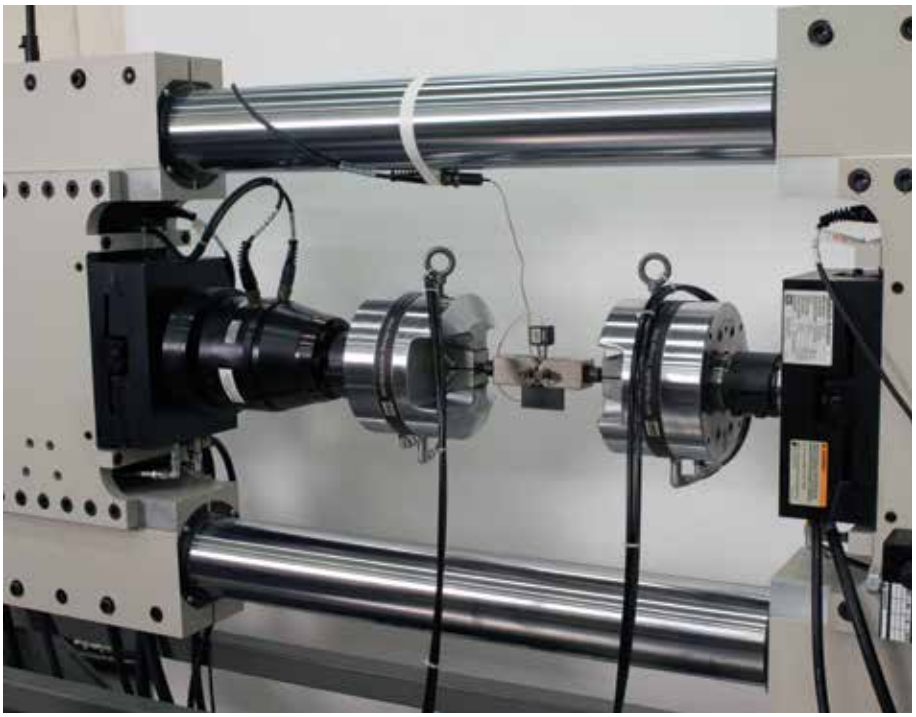
"As advanced as this technology may sound, the load frame portion of the system is central to its successful use for material characterization," said Dr. Peter Liaw, principal project investigator from UT. "Since the neutron beam is in a fixed position, the load frame and its control system must achieve extreme precision to keep the specimen centered within the beam while applying the specified torque, tension, and compression. And all of this must occur within a high-radiation and high-activation environment. A standard load frame system clearly wouldn't do."

"The load frame system must also be light enough to facilitate easy switching from a vertical to horizontal orientation, yet highly stiff to minimize specimen buckling during low-cycle fatigue testing at high strains," added Dr. Xun-Li Wang. "The engineering challenges associated with achieving this capability were enormous."

MTS SOLUTION

To overcome the challenges of developing the multiaxial load frame, the VULCAN development team chose to partner with MTS for two primary reasons: experience and customization capabilities.

"One of our main purchasing criteria included a demonstrated ability to understand and creatively resolve unique mechanical testing problems," said Amy Black, lead ORNL engineer on the VULCAN project. "MTS was a clear standout in this regard, with a long history of successes to show for it."



"Dozens of MTS test systems are also in use at other areas of the ORNL facility, and feedback has been unanimously positive from these groups." added Dr. Wang.

By June 2010, the VULCAN diffractometer will be fully operational, with a one-of-a-kind, multiaxial MTS load frame serving as the functional — and visual — centerpiece of the installation. With unprecedented flux and advanced instrumentation, the instrument will allow extremely fast in-situ volumetric material loading studies, including the ability to study kinetic behaviors in sub-second times.

In-situ studies include temperature distribution, texture changes, and stress development and precipitation, in both extremely high-temperature and cryogenic operating environments. The VULCAN system also facilitates the simultaneous characterization of dilatometry, weight and microstructure, yielding a highly accurate and detailed snapshot of a material's atomic state at any moment in time.

CUSTOMER BENEFITS

"The VULCAN diffractometer stands to significantly advance the materials science body of knowledge; its potential uses are endless," Dr. Liaw said. "Its capabilities will be especially useful at a time when many new and unfamiliar materials are being developed to address the world's most urgent issues, including energy-related problems."

"We're operating at the very forefront of the industry here, and we were breaking new ground nearly every step of the way during VULCAN development," said Black. "MTS was one of the few companies out there that could creatively meet such formidable engineering challenges. Our collaboration with UT and MTS has brought together experience and expertise in a wide variety of fields and the result is a unique, multiaxial load frame that will complement and enhance the VULCAN Engineering Diffractometer at SNS."

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