Improved Method for Testing Transportation Materials

Heavy Vehicle Propulsion System Materials

U.S. Department of Energy

Energy Efficiency and Renewable Energy Program

Oak Ridge National Laboratory

UT-BATTELLE

Transportation

FOR THE 21ST CENTURY

Background

In support of the Heavy Vehicle Propulsion Materials Program sponsored by the U.S. Department of Energy (DOE) Freedom Car and Vehicle Technologies Program, the Oak Ridge National Laboratory has developed a unique method for determining the intrinsic fracture toughness values of materials, including thermal barrier coatings used in various components of heavy vehicles. Because of its innovative concept, rigorous theoretical basis, and simplicity in methodology, the test method was selected as a winner of a 2002 R&D 100 award. The R&D 100 awards are given annually for the 100 most significant technologies developed in that year.

Fracture toughness is a key element used, among other criteria, as a basis for setting standards in structural design to guard against uncontrolled catastrophic failure of materials. Until now, however, test techniques have yielded only a gross approximation of fracture toughness. The ORNL Spiral Notch Torsion Test (SNTT) system provides a more precise measurement to solve this problem.

The Technology

Current test methods using small specimens are not fully in compliance with fracture mechanics theory in the rigorous sense. Until now, a rigorous measurement required meeting ASTM Test Standard E399, which requires large and expensive samples. As a result, K_{IC} values derived from small specimens were deemed approximate. The new test method does not suffer the volume restriction, and test results are independent of specimen size.

The SNTT system operates by applying pure torsion to unique cylindrical specimens having a machined V-notch that spirals around the surface at a 45 degree pitch.

The crack produced is controlled, propagating toward the central axis of the specimen; having this control produces consistent results. K_{IC} is evaluated from the torque at fracture and the final crack length with the aid of an ORNL-developed three-dimensional finite element analysis code.

Future Directions

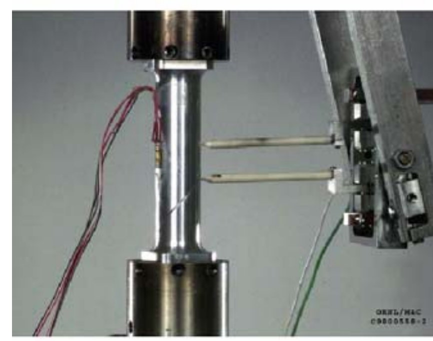
Because the specimen diameter does not play a role in determination of K_{IC}, the specimen can be significantly miniaturized. This unique feature permits the testing of evolving new experimental materials available only in small volumes; materials having texture and gradient, such as the heat-affected zone of a weld; thin films; and thermal barrier coatings. Many of these materials represent much-needed future technologies for the improvement of energy efficiency and performance of advanced engines.

Commercialization

ORNL is currently negotiating with several interested companies to license the SNTT technology. The plan is to develop a small, portable instrument that can be marketed to a broad range of users, including materials suppliers, testing laboratories, and component and engine manufacturers. The technology is expected to have applications in other fields as well, such as nuclear engineering and mechanical systems.

Benefits

- The SNTT system offers a means to determine reliable fracture toughness for a wide spectrum of materials that are produced in limited volume or in thin coatings.
- The new method can significantly reduce the cost and iteration time of developing new materials.



Typical SNTT sample set-up

For more information on how ORNL is helping America remain Competitive in the 21st century, please contact:

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Success Story

November 2002