Friction Stir Processing of Advanced Materials

Lightweight Materials

U.S. Department of Energy

Energy Efficiency and Renewable Energy Program

Oak Ridge National Laboratory

UT-BATTELLE

Transportation

FOR THE 21ST CENTURY

Background

An essential strategy for reducing the weight of automobiles is increasing the use of lightweight materials, such as aluminum or metal composites that combine metals with other materials. However, difficulties associated with welding these materials contributes to their limited use in many automotive components. Traditional welding processes melt metal. Unfortunately, melting can destroy the carefully engineered microstructures of composites thereby eliminating their unique properties. Even in aluminum sheet or castings, a number of significant issues arise from welding. For example, when resistance spot welding aluminum sheet, undesirable chemical interactions can occur between the aluminum and the welding equipment. This can contribute to weak welds and it can accelerate the deterioration of welding equipment. Welds made in aluminum castings can contain porosity. They can also be susceptible to cracking associated with the metallurgical changes that occur during localized melting.

New technologies are being sought for joining these advanced lightweight materials, and for modifying their surfaces to further improve their properties.

The Technology

Friction stir welding, a relatively new process, is a solid state joining technology that has become well established for producing high-quality welds of aluminum alloys. Instead of a conventional welding torch, friction stir welding uses a rotating, non-consumable tool that is moved along the length of the joint in the material. The tool works heated materials into close contact, causing them to form a solid state joint. No melting of materials occurs; instead, the joint is formed by plastic deformation of the pieces.

Friction stir welding should be capable of welding many types of similar and dissimilar material combinations that are difficult or impossible to weld using conventional methods. Tests on aluminum castings show that metal hardness is maintained in the joined areas and that the ductility of the friction-stir-weld is superior. Such improvements could have important implications for manufacturing critical cast aluminum components for a variety of automotive applications.

Friction stir processing also can be used to modify microstructures to improve the surface properties of metals, a capability that is of particular interest for transportation applications. ORNL's research is focusing on this aspect of the technology for use with automotive alloys. Cast aluminum alloys, such as A319, are used for suspension and drive line components in automobiles. The microstructure of cast A319 contains coarse eutectic and porosity. Research indicates that friction stir processing can refine the size of the eutectic constituents, making the microstructure finer and therefore stronger. It also closes pores that are open to the surface of the material.

ORNL is preparing to install a new, state-of-the-art friction stir welding system. This equipment will be used for a wide variety of research and development related to improving the basic understanding of the friction stir welding process and how it affects the properties of materials. Additional activities will seek to develop improved tool materials for making friction stir welds, to apply the process to a wider range of materials, and to develop new applications for the process.

Commercialization

ORNL is working with Ford Motor Company and the South Dakota School of Mines and Technology to explore possibilities for using friction stir processing to improve the surface properties of aluminum alloys.

Benefits

- Friction stir processing can be used to improve microstructure to improve the surface properties of metals.
- Friction stir welding has potential for joining similar and dissimilar materials that cannot be welded by conventional processes.
- Because no melting of materials is involved, friction stir welding avoids the weaknesses caused by distortion and metallurgical reactions in conventional welding.

Friction stir welding apparatus at ORNL uses plastic deformation of the metal to join plates.

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

Phil S. Sklad, Manager
Lightweight Materials Program
Metals and Ceramics Division
Oak Ridge National Laboratory
(865) 574-5069
skladps@ornl.gov

Success Story

November 2002