New spin on friction-stir

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ORNL researchers (from left) Zhili Feng, Stan David and Alan Frederic display a length of wire more than 15 feet long fabricated with the friction-stir extrusion method. They eventually ran out of the magnesium-aluminum alloy feed stock. Friction-stir extrusion is an energy-efficient method for making wire from high-temperature, recyclable materials.

(PhysOrg.com) -- Researchers Zhili Feng, Alan Frederic and Stan David in Oak Ridge National Laboratory's Materials S&T Division have made significant progress toward a new metal processing technique, called friction-stir extrusion, that could represent a major advance in converting recyclable materials -- such as alloys of aluminum, magnesium and titanium alloys, and even high-temperature superconductors -- to useful products.

The process also represents a step forward in energy-efficient industrial processes in that it eliminates the melting step in conventional metal recycling and processing. The friction-stir method, as the name implies, derives its heat from spinning metal against metal, and direct conversion of mechanical energy to thermal energy as frictional heat generated between two surfaces.

The ORNL team produced a solid wire of a magnesium-aluminum alloy from machined chips, eliminating the energy and labor intensive processes of melting and casting.

"This process is very simple. You get the product form that you want by just using the frictional heat," said Stan David, an ORNL retiree and consultant who once led the division's Materials Joining group.

The new approach provides an opportunity to efficiently produce highly engineered structural and functional materials. Friction extrusion can be developed into metal recycling process of steels, Al alloys, and other recyclable metals. It is suitable to produce a variety of bulk nano materials such as nano engineered ODS alloys. It also has the potential to produce nano grain structure bulk materials. The impact of economically producing nano engineered creep resistance Al conductors in large quantity will be enormous for the power transmission industry.

Friction-stir extrusion could also represent a new route to the fabrication of extremely specialized materials, such as high-temperature superconducting wires and mechanical alloyed materials.

"The process of melting and casting can destroy the properties of a highly ordered, novel material such as an oxide dispersion strengthened materials or a high-temperature superconductors. Because friction-stir only takes the material up to 'plasticizing' temperatures, the properties of the material are not affected as much," said Zhili Feng, who now leads the ORNL group.

The extrusion process follows the same principle of the friction-stir welding, in which a rapidly spinning tool is applied to the metal, heating

it until it becomes soft, but not melted. Because the material is still in its solid state when it is extruded, it suffers none of the degradation and transformation that would occur with actual melting.
"The process of melting is very detrimental to those properties," said Feng.

Wayne Thomas, who pioneered the friction stir technology at The Welding Institute in England, says ORNL has proved the basic principle of a new technique that could be key to working with advanced alloys, including high-temperature superconductors.

"It is very difficult to mix silicon, titanium, magnesium and other materials in to alloys and turn them into molten metals. If you can mix them in the solid phase, it is much better, and there are mixtures you can't even consider outside a solid phase," Thomas said.

One such application is the fabrication of mechanically alloyed magnesium alloys into components. Friction-stir extrusion has potential to be a low-cost way to produce product forms with this lightweight and high-performance metal. ORNL is extensively involved in the magnesium alloy R&D and technology transfer and commercialization.

The energy savings of this process are significant: The process requires only 10 to 20 percent of the energy required for conventional melting with potential saving of more than 80 percent.

The team credits DOE's Industrial Technologies Program for a capital equipment investment and programmatic funding that enabled them to establish the prototype friction-stir work station at ORNL. The ORNL team is already seeing industry interest in what they've accomplished so far with the technology. One of the companies is Southwire Company, a major international electric cable company, that is currently working with ORNL on the technology development.

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