the ENERGY lab

PROJECT FACTS

Advanced Research Materials

Improved Atomization Processing for Fossil Energy Applications

Background

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) sponsors the development of innovative, cost-effective technologies for improving the efficiency and environmental performance of advanced power systems. These emerging technologies require development of high-performance materials that can withstand demanding high-temperature, high-pressure, and often corrosive environments. Power system components made with materials that perform well in high temperatures may be coated by thermal spraying with high-melting point alloys that withstand oxidation and corrosion. The manufacturing process that is most suitable for the complex, high-melting-point alloys for these emerging technologies is gas atomization, especially with the use of a close-coupled nozzle.

These nozzles have potential for improvements in efficiency and process control; however, most industrial gas atomization practitioners have not pursued the developments needed to reliably produce specific class sizes of metal powders. Rather, sieves and pneumatic separators are used to separate and collect powder with the desired particle size range and the rest is recycled or inventoried, if possible, or scraped. This conventional practice is process and energy intensive, wasteful of materials, and quite costly, thus making it unacceptable for complex alloy compositions without additional markets. NETL is partnering with Ames Laboratory to develop a close-coupled atomization nozzle and control system that can be calibrated to generate liquid droplets in the atomization spray, which then solidify to the specified size range of particles in powders for specific applications.

Project Description

During this project, researchers will improve the design of high-efficiency gas atomization nozzles in order to maximize powder yields in special size classes most suitable for thermal-sprayed coatings. Sizes will include ultrafine powders, with particle diameters of less than 10 microns (µm), and mid-range powders, with particle diameters ranging between 10 and 44 µm. Powder production tests will be performed in laboratory atomization systems to demonstrate steady-state operation and controls systems suitable for industrial use. Researchers will perform a detailed analysis of atomization process responses to alloy and parameter modifications to verify the effect of process innovations. Initial work will involve pure metals and simple model alloys for each target area of process or alloy development.

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PARTNERS

None

PROJECT DURATION

Start Date
10/01/1998

End Date
09/30/2011

COST

Total Project Value
$1,564,000

DOE/Non-DOE Share
$1,564,000 / $0

Researchers will focus on two control procedures to provide the level of atomized powder size control needed for the discrete jet close-coupled atomization nozzle of this project. First, an increase in the efficiency of the melt disintegration process will be targeted to produce high yields of ultrafine powder. This will be approached by adjusting the gas jet arrays to affect the supersonic gas flow pattern, and by choosing the optimum atomization gas. Second, researchers will control droplet size to minimize ultrafine powder yield and increase intermediate powder yield (particle diameter approximately 30 μm). This will be accomplished by using gas flows of reduced energy with atomization nozzles of different array diameters and advanced orifice designs. The addition of reactive gas components will be investigated to generate metastable surface films on precursor powders to serve as a chemical reservoir for subsequent exchange reactions during consolidation and heat treatment of dispersion-strengthened alloys.

Goals and Objectives

The goal of the project is to enable cost-efficient production and widespread use of metal powders by developing a nozzle and control system for gas atomization that can be calibrated to produce specified particle size ranges. Specific project objectives include developing optimized gas atomization nozzles; process optimizations for gas atomization reaction synthesis (GARS) processing of precursor powder for oxide dispersion strengthened (ODS) iron-based alloys; production of prototype batches of ultrafine high-temperature alloy powder in sufficient quantity for subsequent powder processing trials; production of a batch of intermediate-sized alloy powder in sufficient quantities for thermal spray trials; and mechanical testing and microstructure analysis of powders and consolidated alloys.

Accomplishments

Previous collaboration with LANL on partially sintered ultrafine iron aluminide powders as porous supports for hydrogen separation membranes resulted in US Patent No. 7,611,565 B1, issued on November 3, 2009. Project team members developed an innovative processing method involving GARS for the fabrication of precursor ODS ferritic stainless steel powder. The resulting consolidated microstructure evolution was evaluated; initial as-consolidated tensile properties were compared with data on commercially produced mechanically alloyed ODS ferritic stainless steel alloys. The first US Patent on the general approach to generation of dispersion-strengthened alloys from GARS powders was issued on April 20, 2010, with two additional patent applications under examination. A project begun in December 2009 with a major industrial partner is based on this new simplified ODS alloy production technology.

Benefits

This project will extend the benefits of powder metallurgy within and beyond the fossil energy field. The ability to harvest high yields of specific sizes of powder particles will significantly lower the costs of specialty metal powders. This will enable their use in such high-performance materials as ODS alloys and open the way to more effective alloy production processes for industries serving the fossil energy market. The resulting alloys will be used in applications including coal gasifier heat exchangers and gas turbine blades. Further development of other metals may be used to fabricate components such as hydrogen separation membranes. These developments will enable more efficient power plants operating with reduced emissions and adaptability to carbon sequestration or capture.

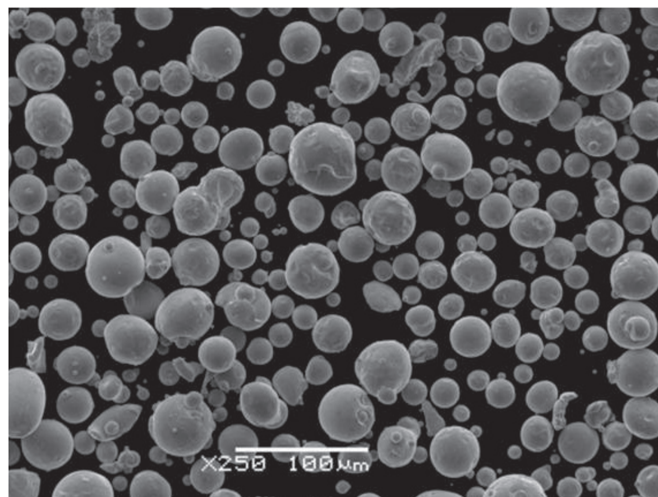

Figure 1. Atomized powder