Advanced Industrial Materials Program

Project Fact Sheet

Advanced Materials Processing with Uniform-Droplet Spray Process

Benefits

- Production of advanced particulate materials with tightly controlled size and microstructure
- Deposition of sheet, near net- and net-shapes having novel microstructures
- Lower energy use, capital, and operational costs relative to conventional powder production processes of up to 40%, and benefits for spray deposition processes of up to 25% over conventional casting and rolling operations

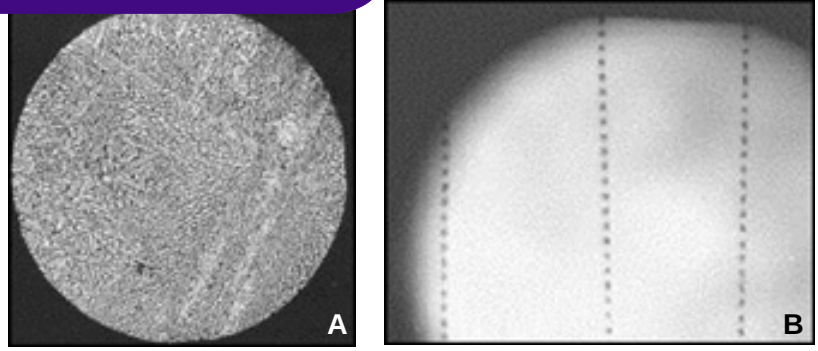
Applications

- Mono-sized particulates applications include metal injection molding, hot isostatic pressing, controlled alloy addition in alloy making (mono-sized shots, ball-grid array electronics packaging), water filtration systems, ball bearing production, etc.
- Applications for advanced spray or droplet deposition include the continuous production of flat materials (sheet, strip, coatings), net-shape spray deposition, rapid prototyping, monolithic and composite coatings, and functionally graded materials

The Uniform Droplet Spray (UDS) Process Enables Efficient Production of Mono-Size Powder and Sheet of Engineering Alloys

The Uniform Droplet Spray (UDS) process enables production of advanced particulate materials with tightly controlled size and microstructures. The implementation of the UDS process in powder production results in lower energy use, capital, and operational costs relative to conventional powder production processes of up to 40%. Utilization of the UDS process for continuous sheet materials production can result in improved energy and operational efficiencies through fewer unit operations including rolling, sheet with near net thickness, and elimination of reheating stages. Improved microstructural control leads to materials with enhanced properties. These features can also be realized in near net fabrication of parts where tooling and rework are minimized while maximizing materials properties.

Powder cross section and UDS multiple spray



(A) microstructure of uniform droplet produced Al-6Cu-0.4Zr spheres; (B) multiple orifice system enables higher throughput rates for producing uniform diameter metallic droplets.

Project Description

Goal: The goal of this project is to develop the uniform-droplet spray (UDS) process for producing metal powders and sheet materials of engineering alloys. Systematic studies are conducted to optimize process parameters, understand the solidification of droplets and spray deposits, and develop systems for processing engineering alloys.

Two important areas of materials processing are addressed: advanced particulate production and advanced spray/controlled droplet deposition. Materials studied in the particulate area include mono-sized spheres (at present 40 to 1000 micrometer diameter) and flakes, splats, or sheets of metals and alloys. Droplet deposition enables process improvements from coatings to near net-shape spray deposits and prototypes which are characterized by novel microstructures produced with fully de-coupled spray and substrate parameters. Materials evaluated include low-, medium-, and high-melting point alloys.

The UDS process permits control of the solidification of the droplets in both particulate production, and spray and controlled droplet deposition. In particulate production, the droplets are either solidified in flight or individually quenched at a flight distance that corresponds to a desired thermal state. Quenched particulate materials are differentiated from their conventional counterparts by the fact that the individual particles all have an essentially identical rapid solidification microstructure leading to improved properties. In-flight solidified particles are suited for applications where size uniformity and sphericity are primary requirements. In spray/controlled droplet deposition, droplets are deposited, in a desired thermal state, into a porosity-free net-shape spray deposit having a novel microstructure. Fine, equiaxed microstructures, rapidly-solidified columnar and single crystals, net-shapes, sheet, and strip have been produced.

The mass production rate of the process depends on droplet diameter, alloy density and the number of orifices configured in a droplet generator, and, with a 100 orifice droplet generator, is estimated to be from 50 to 150 kg/h for 200 micrometer droplets of aluminum, steel, or other engineering alloy. Sets of multiorifice generators can be simultaneously used in one spray chamber leading to lower energy, capital, and operation costs, as well as reasonably high production rates.

Progress and Milestones

- UDS process has been shown to reach temperatures as high as 1250°C
- Multiorifice spraying unit completed and aluminum-based materials produced
- Studies continue on deposition/microstructure relationships
- Pilot scale spraying of materials with melting points from 1000–1100°C has been successful
- Two companies have licensed the technology for commercialization
- Commercialization activities related to alloys with melting point temperatures of less than 1200°C will begin in 1999

Project Partners

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