Pulse Combustion Spray Drying

By James A. Rehkopf, President, Pulse Combustion Systems, San Rafael, Calif.
Posted: September 1, 2006

Powders that undergo pulse combustion spray drying often feature improved particle characteristics and size distributions compared to conventionally spray-dried materials.

Detail of a combustor / atomizer unit.

Users of ceramic powders have spray dried their slurries for many years. Compared to conventional spray drying, however, pulse combustion drying often produces superior powders. Pulse-dried powders are uniformly atomized and quickly dried, yielding improved particle characteristics and tight size distributions.

Pilot-scale pulse combustion spray

Atomization and Particle Size

Conventional spray dryers atomize the liquid feed into a fine sheet in one step through a high-pressure nozzle or a high-speed rotary disk. In addition to the high maintenance costs involved when processing an abrasive or corrosive feed, these types of atomization systems are not very flexible. Conventional spray dryers impose a narrow operating range for the viscosity and solids content of the feed material, providing limited opportunity for product improvement.

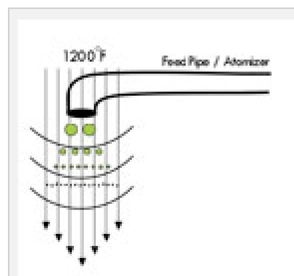

Figure 1: A slow low pressure feed is introduced into a fast, pulsating hot gas stream, which atomizes the feed through a process of successive division.

On the other hand, pulse combustion dryers use gas-dynamic atomization, wherein a low-pressure, slow-moving liquid feed is introduced into a pulsating, very-high-velocity gas stream. The initial droplet is quite large, because the feed introduction nozzle is a straight pipe with no restrictions. As soon as the low-energy droplet experiences the high energy of the gas stream, it begins to divide **(see Figure 1).**

The particle size of pulse-dried powders, which is inversely related to the energy of the atomizing hot gas stream, can be easily manipulated during gas-dynamic atomization. Since this energy is generated in a state-of-the-art pulse combustor, it is very easy to control and change, and it has a high bandwidth. The other major influencer of particle size is the viscosity of the feed, and the relationship is direct. Fortunately, viscosity is very easy to change for most solutions and slurries, and high viscosities are not a problem for the pulse dryer; as mentioned previously, the feed introduction system is basically an open pipe.

Drying Speed

Another difference between conventional spray dryers and pulse combustion drying is the speed of drying. In a conventional spray dryer, the difference between the dryer's inlet air temperature and the outlet air temperature (the Delta-T) is not very large, and there is only modest mixing between the hot air and the atomized droplets. Therefore, it takes a relatively long time for the drying air to mix with the water droplets, and there is not much thermal energy available for evaporation. The reverse is true in a pulse dryer. Since the pulse combustor easily and safely generates a gas stream of up to 2000.F, and since outlet temperatures are similar to a spray dryer's, the Delta-T is remarkably large and efficiencies are high. The most dramatic difference in rapidity of drying, however, is in the mixing. The hot air supplied by the pulse combustor is the same high-velocity gas stream used for atomization. Thus, atomization and evaporation occur at exactly the same point in space and time, and under extremely turbulent conditions. (Imagine how quickly your wet car would dry if you were able to drive it at 400 mph through a 1500°F desert.) For slurries, the drying time is less than half a second.

Case Studies

In their search for improved performance, three companies have recently performed developmental trials using a pilot-scale pulse combustion spray dryer.* American Ceramic Technology, Inc. (ACT) of San Diego, Calif., is a manufacturer and developer of ceramic products. According to Dick Culbertson, president, the nozzle and air flow capabilities available in the pulse combustion spray dryer have enabled ACT to dry high-binder-content materials with a broad particle size range while controlling the moisture in the powders. The improved powders consistently provide higher green density substrates when used in ACT's proprietary roll compaction processes.

Altair Nanotechnologies, Reno, Nev., produces nanosized ceramic materials of very high purity. According to Bruce Sabacky, vice president, R&D, the pulse-dried powders made from Altair's zirconia-based slurries were finer than those produced by conventional spray drying, allowing Altair to press the powders to a higher density. For Altair's energy storage materials, the pulse dryer made a powder with a tighter particle size distribution and no undesirable alterations to the product.

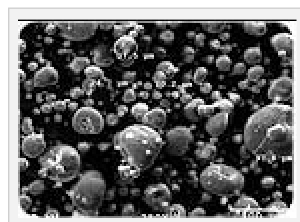

Figure 2: The conventionally spray dried material suffers from a variety of Undesirable properties, including hollow and toroidallike spheres and doughnuts.

*Tests were performed at the Payson, Ariz., facilities of Pulse Combustion Systems.

Altair's unit operations include several spray drying steps, and contamination from the burner on the conventional spray dryer is a constant problem. The company has not experienced this problem with the pulse combustor, which provides precise control of the fuel/air mix.

Another company has tested a silicon-based non-oxide ceramic. According to the company, its spray-dried material has undesirable hollow and toroidal-like spheres and doughnuts, and many particles have a thin crust on the surface **(see Figure 2).** By contrast, the pulse-dried particles feature an agglomerate morphology with solid spheres and some solid doughnuts **(see Figure 3).** The company also reported that preliminary densification trials with small test bars indicated a slightly higher density for the pulse dried powder when compared to the conventionally spray-dried material.

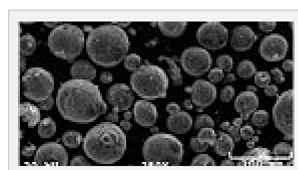

Figure 3: The pulse dried material features solid spheres and some solid doughnuts.

While the pulse-dried ceramic powder compared favorably in many ways to the spray-dried powder, the initial pulse drying trials identified several features that require additional attention and development:

- Some agglomerates were present on a 30-mesh sieve after screening; however, these were easily removed by subsequent screening.
- A considerable portion of a 40-lb run (>20%) remained in the pulse dryer after the drying run was completed, and it was collected during a blow down of the dryer.
- The powders did not flow through a standard hall funnel for flow testing.

It's expected that these issues will be resolved through additional testing in the pilot scale dryer.

Other Benefits

In addition to improved powders and higher efficiency, gas-dynamic atomization provides lower maintenance costs than conventional spray drying. Since the feed introduction system uses a low-pressure pump and a straight pipe, the feed system experiences almost zero abrasion, and corrosive feeds can be handled with simple tube pumps. Not only are maintenance costs reduced, but contamination of high purity products is also reduced or eliminated.

For more information about pulse combustion spray dryers, contact James Rehkopf at Pulse Combustion Systems, 135 Eye St., Suite B, San Rafael, CA 94901; (877) 854-1062 or (415) 457-6500; e-mail jrehkopf@pulsedry.com; or visit http://www.pulsedry.com/.