How To Dry Bulk Material Effectively

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Spray, rotary, flash, tray and fluid bed dryers: Each is best suited to particular applications. This overview will help you know which is best for yours.

The large and growing list of methods to dry bulk materials has narrowed the applications in which each category of dryer excels. The latest example is fluid bed drying, where circular fluid bed designs have intruded on turf previously dominated by rectangular units. This article updates specifiers by comparing fluid bed dryers with other methods in general and circular fluid bed designs with rectangular designs in particular.

Comparing fluid bed dryers with spray, rotary, flash and tray dryers is highly application dependent. Usually, the nature of the drying problem dictates the type of dryer to use or limits the choice to two or three possibilities. Considerations for selection include the feed's moisture content and form of the feed -- liquid, semisolid, free-flowing. What is its sensitivity to heat, agitation? What is the dryer's ability to handle the feed? What is the capacity requirement? Can the feed be preconditioned?

Where fluid bed dryers fit among available choices hinges on how closely your process parameters and material characteristics dovetail with the dryers' capabilities. Various dryers occupy niches for high-water-content or solid feeds. Fluid bed dryers mainly handle solid feeds composed of discrete particles -- with exceptions. Fluid bed processors also can cool or moisturize when the heating unit, located between the blower and fluid bed processing unit, is substituted with a remote chiller or a moisturizer.

Dryers For High-Water-Content Feed

Liquid and pumpable semisolid feeds such as slurries are best suited for spray, rotary or drum dryers.

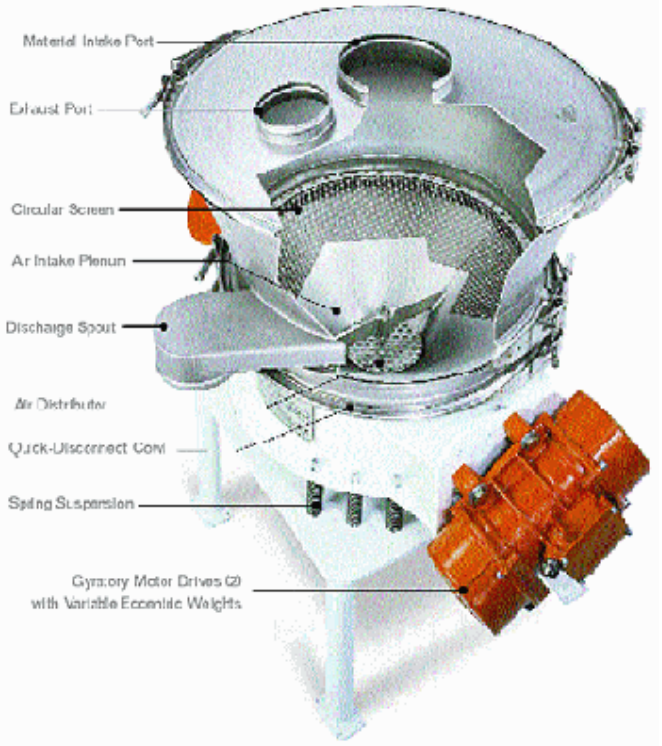
A spray dryer dries liquid or slurry feeds at high rates. The slurry is atomized, and the droplets are dried in contact with a hot airstream. Moisture is vaporized rapidly from the droplets, leaving residual particles of dry solid. Dwell time is very short, permitting drying of heat-sensitive materials. Because the droplets must not strike solid surfaces before drying is complete, drying chambers are necessarily large -- 8 to 30' dia. with dryer heights as much as 80'. Much heat is lost in the discharged gases, reducing efficiency of spray dryers.

A rotary dryer processes liquid, pumpable and nonpumpable semisolids, and free-flowing particle feeds at high throughputs. The dryer consists of a rotating cylinder, slightly inclined from horizontal, in which a hot airstream dries as it flows parallel or counter to the feed. As the cylinder rotates, internal flights lift and shower down the solids through the interior of the shell. The dryer also can operate under vacuum for drying heat-sensitive materials at lower temperature. The rotary dryer's horizontal configuration, however, can consume much floor space. It is energy intensive and incurs relatively high initial cost.

Dryers For Solid Feeds

Flash, tray, rotary tray and fluid bed dryers are among the most popular methods for drying solid and semi-solid feeds in the form of cakes, powders and granules.

A flash dryer dries preconditioned particles at high throughput rates. A heated pneumatic conveying system entrains the particles in a hot airstream. Temperature is high -- up to 1,200°F (649°C) -- at the flash dryer inlet, but the feed temperature rarely rises above 90°F (32°C) because residence time is short -- between 0.5 and 10 sec. Thus, flash drying can process heat-sensitive materials that otherwise would require indirect drying by a lower temperature method. (Indirect drying transfers heat through a medium such as pipes or a retaining wall rather than putting the product in direct contact with the hot gas or air.)



In a circular fluid bed processor, material vibrates on screen within a rising column of heated, cooled or moisturized air. The continuous airflow and vibration separate and fluidize individual particles, maximizing surface area of the material and, accordingly, the rate at which drying, cooling or moisturizing occurs.

A flash dryer is energy intensive and requires high volumes of hot air. Configurations include a single long tube, a loop design and a series of cyclones. Its vertical configuration may require a costly multiple floor support structure.

Tray dryers are useful for low capacity applications and for material that cannot be agitated. A tray dryer consists of a housing into which shelves or trays of material are manually loaded, around which a hot airstream circulates. Labor required for loading and unloading can make them costly to operate.

For precise temperature control, a rotary tray dryer houses a stack of rotating circular trays within a hot airstream, creating different temperature zones. After one tray revolution, a wiper sweeps the material to the next lower tray, with the same action repeating for the entire stack of as many as 20 trays. The feed discharges as dry product at the bottom of the housing.

Fluid Bed Drying

In general, fluidized bed drying is suited for products containing 40 percent or less moisture -- the point at which most products become free-flowing enough to fluidize in the fluid bed chamber. The feed must be in the form of discrete particles such as free-flowing powder, granules, crystals, flakes or pulverized material that can be fluidized. Depending on the application, fluidized bed drying may provide a simpler process than spray, rotary, flash and other methods. It has few moving parts and relatively low energy consumption.

This 48" dia. fluid bed dryer reduces moisture content of 50 micron mesh size ceramic particles from 7 percent to 2 percent at a continuous rate of 1,000 lb/hr.

Fluid bed operation can be batch or continuous. Continuous operation requires a feed control device such as a screw feeder, belt feeder or rotary valve. Batch processing normally employs a discharge spout gate that remains closed while the batch is being dried and opens after the drying run is complete.

In operation, material vibrates on a screen or perforated surface within a rising column of heated air. The continuous airflow and vibration separate and fluidize individual particles, maximizing the surface area of material exposed to the hot airstream. Particle fluidization eases material transport for gentle handling of the feed. Fluidized bed drying produces high thermal efficiency while preventing overheating of individual particles, making it a good choice for temperature-sensitive products.

Residence time of products within a circular fluid bed dryer operating continuously ranges from 30 sec to 15 min. For heat-sensitive materials, shorter residence times are preferred. Air temperature can be reduced to below the material's temperature limit as a precaution. Residence times for batch fluid bed drying can extend as long as necessary to attain the desired drying level and can be varied using an adjustable gate at the discharge spout called a "weir."

With fluid bed drying, any fines carried into the exit airstream can be recovered downstream by a cyclone separator (effective to around 30 micron level) and a dust collector.

Exceptions To The Rule

While semisolid lumpy or caked feeds are normally handled by rotary, tray, flash, plate or conical dryers, a fluid bed dryer can be utilized, providing a granulator/delumper or centrifugal sifter is installed upstream to precondition the material into discrete particles.

A delumper can chop large, solid pieces into particle sizes of approximately 0.25". Smaller particle sizes can be produced by a centrifugal screener that employs rotating helical paddles that propel particles continuously against and through a perforated plate cylindrical screen. On-size particles fall through the center of the screener and feed into the fluid bed dryer. Any particles discharged from screener's oversize spout can be reintroduced into the screener until all achieve uniform size.

One typical application utilizes a centrifugal screener to continuously delump a nonflowing, sticky cake of ceramic particles into 50 micron mesh particle sizes while a 48" dia. fluid bed processor reduces moisture content from 7 percent to 2 percent at a continuous rate of 1,000 lb/hr. Tem-perature is below 212°F (100°C). The self-contained drying system consists of heater, blower, fluid bed dryer and cyclone separator.

For high-moisture-content feeds, a fluid bed dryer also can function as a second stage immediately downstream of a spray or rotary dryer. A spray dryer, for example, might be intentionally undersized, only capable of lowering moisture from 80 percent to 30 percent. A

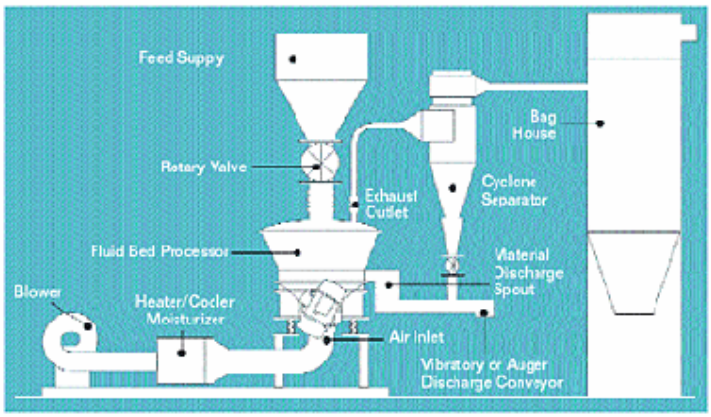
second-stage fluid bed dryer can reduce the moisture content from 30 percent to the desired final moisture content.

Similarly, a high-moisture-content feed such as sludge, paste or wet cake can be preconditioned -- for example, dewatered by a filter press, simple screen or centrifuge -- upstream of the fluid bed dryer. An additional delumping step also may be needed.

Back mixing -- mixing dry material with incoming wet material before a centrifugal sifter or preconditioning device -- also is employed to reduce the material's moisture content before it enters the fluid bed dryer. Inherent in a circular fluidized bed's design is internal back mixing, which may permit drying of material containing moisture in excess of 40 percent. As the feed is introduced near the center of the circular chamber, it mixes immediately with the fluidized, partially dry material that has been spiraling outward in a controlled pathway from the center of the chamber. Adjusting the feed rate determines how thoroughly this mixing takes place. Controlling the bed depth by raising the height of an adjustable weir at the discharge spout prolongs the mixing and dwell times to increase dryness.

Fluid Bed Cooling, Moisturizing

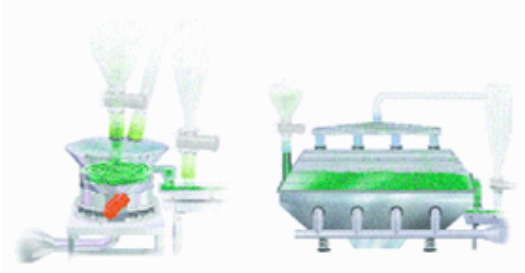
Fluid bed processing can also be employed for cooling and moisturizing of bulk material within a rising column of chilled or moisturized air. This can be accomplished by placing a heat exchanger with remote chiller, or moisturizer, between the blower and fluid bed processor.



A circular fluid bed processing system includes blower, heater, cooler or moisturizer, cyclone separator and baghouse to recover fines.

In one example, a plastics compounder cooled a moisture-sensitive cellulose-plastic compound to 100°F (38°C) and less than 1 percent moisture in a few seconds at a rate of 4,000 lb/hr. The 60" dia. processor is mounted on a skid with 10 hp blower, cooling unit, dust collector and control panel. The mobile unit cools most of the plastics produced in the plant.

Circular Vs. Rectangular



Inherent in circular fluidized bed's design is "internal back mixing," which can accelerate

Rectangular and circular fluid bed dryers have application niches that overlap slightly. Rectangular, horizontal fluidized bed dryers generally process 3 to 4 tons/hr to approximately 50 tons/hr. Circular fluidized bed dryers process 2 lb/hr to 10 tons/hr.

drying of high moisture content material. As the feed is introduced near the center of the circular chamber, it mixes with the fluidized, partially dry material that has been spiraling outward in a controlled pathway from the center of the chamber.

Rectangular fluid bed dryers can be designed with multiple zones with different inlet conditions for each zone. This helps when temperature variations can benefit the process or when products are heat sensitive.

Due to their smaller size, lower energy use and ease of cleaning features, circular fluidized bed dryers make a good choice when the drying rate matches that of rectangular fluid bed dryers. The circular design has no corners or crevices for material to lodge and cause contamination or hamper cleaning. Rectangular fluidized bed dryers of equivalent capacity occupy about twice the space of circular units and require higher airflow, consuming more energy.

The circular design is inherently stronger than rectangular designs, permitting lightweight construction. Materials can be down-gauged and motors and associated components can be downsized, reducing initial and operating costs. A circular fluid bed drying system also can be self-contained on a skid. Equipped with casters, it can be mobile for multiple duties.

Selecting a dryer depends on the nature of the feed, the production rate, energy consumption, space available, fines collection needed, costs of the entire system in addition to the drying unit, and ability to operate reliably, safely and economically. Although some considerations may conflict with one another, ultimately, the user will reach a compromise for the best dryer for the intended service.

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