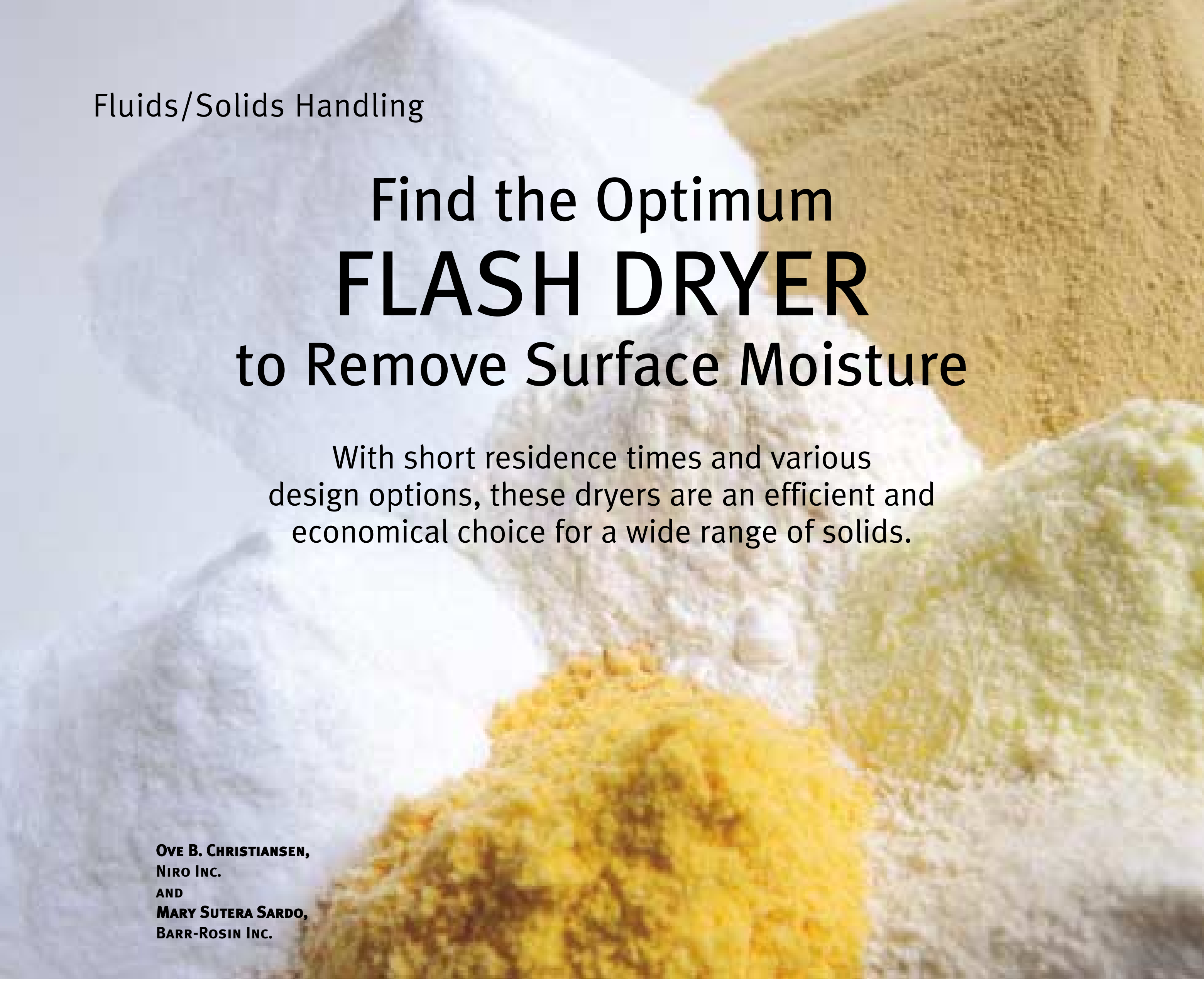

Find the Optimum FLASH DRYER to Remove Surface Moisture

With short residence times and various design options, these dryers are an efficient and economical choice for a wide range of solids.

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Flash dryers can be the most economical choice for drying solids that have been dewatered or inherently have a low moisture content. Also known as "pneumatic dryers," they are the simplest gas suspension dryers with the smallest footprint. A single operation combines the necessary mixing, and heat and mass transfer for drying a solid. Residence time is short, usually less than 3 s, producing almost immediate surface drying.

These dryers are useful for moist, powdery, granular and crystallized materials, including wet solids discharged from centrifuges, rotary filters and filter presses. Particle size must be quite small, generally less than 500 µm, and the best feed is friable, and not sticky.

Due to the rapid drying process, flash dryers are not suitable for diffusion-controlled drying. Figure 1 shows a typical drying curve for a fixed or fluidized bed; the constant drying-rate area where surface moisture is removed is ideal for flash drying. This process is controlled strictly by the heat input, without a residence-time requirement; drying occurs "in a flash."

Advantages

Flash dryers have several advantages over more complex gas-suspension dryers such as fluid-bed or rotary types. As noted above, they are relatively simple and take up less space. Also, they usually require a lower capital investment.

Because of the extremely short residence time, these devices are well-suited for processing heat-sensitive or easily oxidized materials. Evaporation keeps the solid at a low temperature (Figure 1). If the product has no affinity for water,

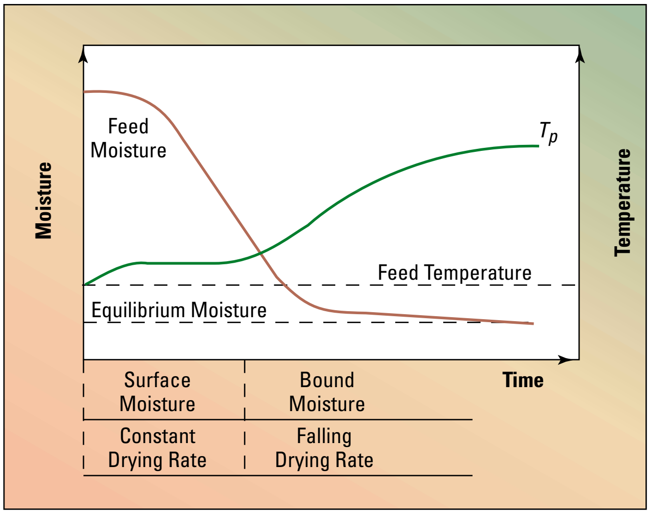


Figure 1. Flash dryers are ideal for removing surface moisture.

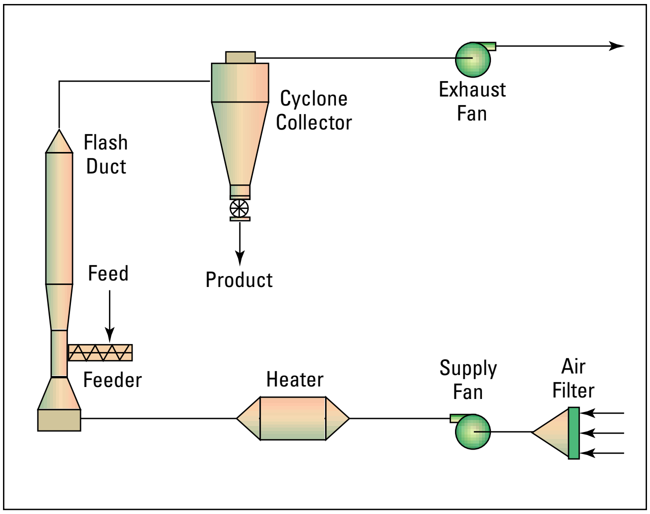


Figure 2. Basic system finds wide application.

the dry powder will assume the wet-bulb temperature. With increasing affinity, the powder temperature, T_p, will increase. Another plus is that the product inventory is low, allowing for minimum downtime in product/grade changes.

Control is simple. Normally, the inlet gas temperature is kept constant and the outlet temperature controls the wet feed rate. If required, the feed rate can be kept constant and the outlet gas temperature will modulate the inlet gas temperature setpoint. The low inventory in the dryer allows the control system to respond quickly to operational changes.

Equipment

The heart of the system is a vertical duct, or flash tube, in which the drying takes place. A fan forces the drying gas (air, or, sometimes, an inert gas such as nitrogen) through a heater and up through the tube. The feed enters the gas stream, which instantly suspends it and carries it to the collection equipment, usually a cyclone or a bag collector. This is similar to pneumatic conveying; indeed, a flash-drying system can be considered a dilute-phase pneumatic conveying system using heated gas as the conveying medium. A basic setup is shown in Figure 2, and, for simplicity, this and the following figures all show a cyclone for product recovery.

A crucial element is the proper dispersion of the wet feed into the gas. The flash tube commonly incorporates a venturi, whose high gas velocity assists in dispersing the solid. For fine, free-flowing powders, a metering device, such as a screw feeder, is adequate. Materials containing soft agglomerates that are easily broken up may call for a feed injector or cascading screen, acting as a fast-moving rotary valve. Hard agglomerates require a disintegrator or hammer mill. This can result in combined drying and milling as in a pulverizing system. There are additional ways to ensure proper dispersion of the solid in the gas, including back mixing of dry solids when dealing with a sticky, nonfriable feeds.

When air is the drying gas, a single induced-draft fan can be used. Alternatively, both a supply-air fan and an exhaust-air fan can be provided to obtain close-to-ambient pressure at the feed entry point. For heating the air, direct-fired gas heaters or steam heat-exchangers are commonly used, but indirect-fired heaters can be selected, if required.

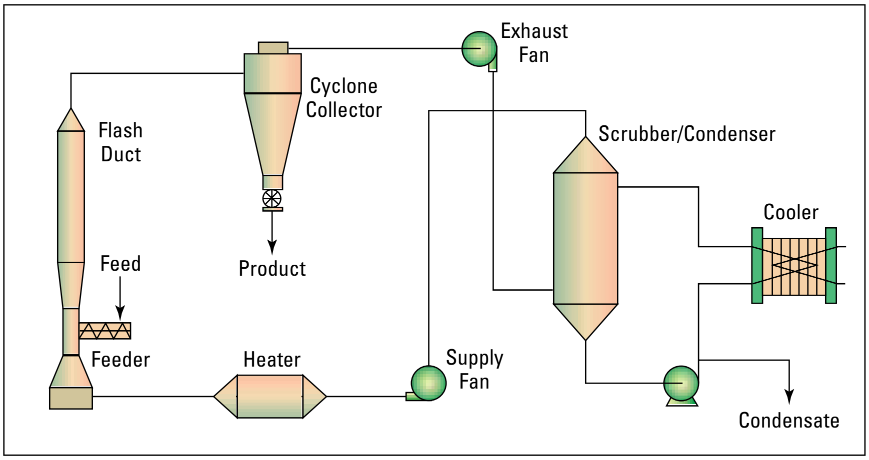
Cyclones are the least costly means of product collection and will capture the bulk of the solid. However, they often fail to meet required emission limits, so bag filters are often used instead of or in addition to them. Where baghouses are unsuitable, the cyclone can be followed by a wet scrubber.

Design considerations

Flash drying systems are designed based on feed and product characteristics, the available or permissible heating source and safety requirements. The dryers can, for instance, be in closed cycle when removing organic solvents (rather than water) (Figure 3). The drying gas is inert (typically nitrogen), and the evaporated solvent is subsequently condensed. In the figure, the condenser is a direct scrubber-type in which the organic solvent is used as the scrubber liquid. The scrubber effluent recirculates through a cooler to remove the heat from the drying process. The condensate drains off and the gas is heated and recirculated by a fan.

Although theoretical calculations can be made, developing design data always requires pilot plant testing, unless there is experience in a plant. The critical data include drying temperatures and product moisture content, but, equally important, are the experience gained in handling the feed and evaluating how it is properly dispersed in the gas.

The simple flash dryer (Figure 2) is suitable for drying a wide range of products, for instance, inorganic chemicals such as sodium bicarbonate, gypsum and alumina, and organic products ranging from native starch to some polymer materials. However, process considerations sometimes call



■ Figure 3. Closed-cycle setup for removing organic solvents.

for design modifications to expand the practical range of these dryers, and so a family of systems is available, all operating within the same basic constraints. The table shows typical uses for flash dryers.

Drying larger particles

The short residence time of 1–3 s requires that the moisture is truly surface water and that the particles in the feed cake are completely dispersed in the drying air. Otherwise, the larger particles may require longer drying times. Since the simple flash dryer is vertical, this allows the larger particles to travel through the flash duct more slowly. However, this is often inadequate to yield a long enough residence time for the larger particles.

Special designs are used when the large particles are agglomerates of smaller ones held together by surface tension. The larger particles will fall apart upon drying and automatically become smaller. One such arrangement is the extended-residence-time flash dryer (Figure 4), in which the flash tube has an upper section with an expanded cross-section to reduce the velocity. The upper section typically contains baffles. This design extends the residence time at the outlet temperature and is used for some polymers.

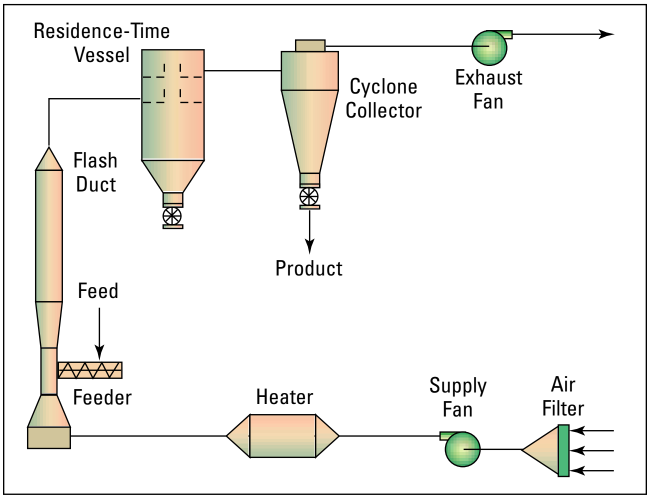
A more elegant solution is the ring dryer, which incorporates a centrifugal classifier (manifold) into the drying loop. The manifold has a series of adjustable deflector blades to control the amount of recirculation within the dryer. The manifold provides selective classification of the larger, wetter particles back to the drying duct for an extended residence time. The manifold produces a lower-moisture product via an outlet temperature below that of a simple flash dryer.

The full-ring dryer (Figure 5) exposes the coarser, recirculated particles to the inlet temperature. A disintegrator in the loop makes this type suitable for thermally stable products such as silica, zeolites and precipitated calcium carbonate.

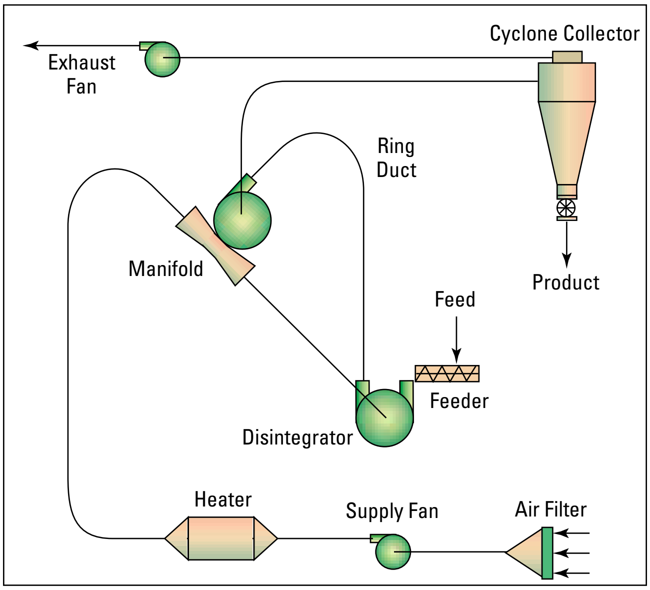
If the feed is heat sensitive, a P-type ring dryer (Figure 6) can be used. Here, the semi-dried particles discharged from the manifold are exposed to the outlet temperature. This design also extends the residence time, and finds use for products such as modified starches and some polymers.

Conserving heat

Owing to the short residence time, the discharged air for most flash dryers is significantly above its dew point. Typically, the relative humidity in the spent drying air is 5–25%. This, together with possible limitations for inlet



■ Figure 4. Extended-residence-time dryer has larger, upper area.



■ Figure 5. Full-ring dryer is used when feed contains some coarser particles.

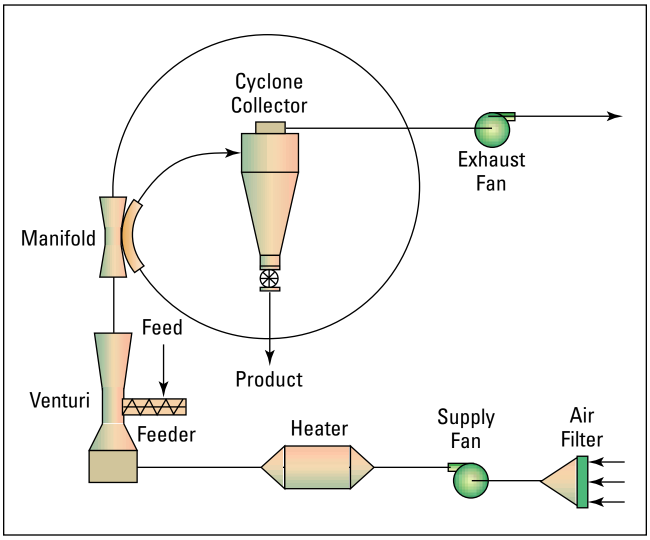


Figure 6. P-type ring dryer extends drying times for heat-sensitive feeds.

Flash Drying Applications	
Alumina	Pigments
Animal Feed	Polyvinylchloride
Calcium Carbonate	Polyethylene
Catalysts	Polypropylene
Cellulose	Polystyrene
Clay	Proteins
Corn Fibers	Silica
Distiller's Grain	Sodium Bicarbonate
Epsom Salts	Starches
Gluten	Synthetic Resins
Gypsum	Wood Flour
Kaolin	Zeolites

temperature caused by product characteristics (*e.g.*, heat-sensitivity), results in a relatively high heat consumption compared with other drying methods.

Heat economy is improved using a two-stage flash dryer (Figure 7). The initial feed is dried in the first-stage unit using the spent air from the second stage. Semi-dried product is then introduced into the second stage, where it is contacted by the hottest air. This system is obviously only feasible if the semi-dried material collected in the cyclone from the first stage is dry enough to avoid clogging this collector. This setup is often used for drying cellulose pulp.

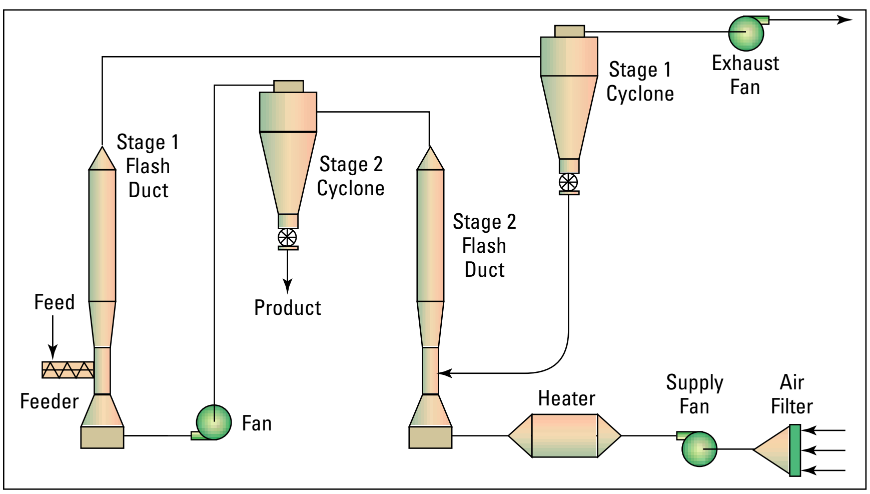


Figure 7. Countercurrent two-stage dryer improves heat economy.

A more cost-effective way to conserve heat is using a partial recycle of the spent drying air (Figure 8). Here, a part of the exhaust airflow is recirculated back to the air heater. The bleed-off stream can be reduced to 25–35% of the total exhaust airflow in Figure 2, lowering the heat consumption and resulting in smaller air-pollution control equipment. In this system, the drying gas self-inerts (it contains less than 10% O_2) if a direct-fired heater is used. Spent grains and waste sludges are often processed in such systems.

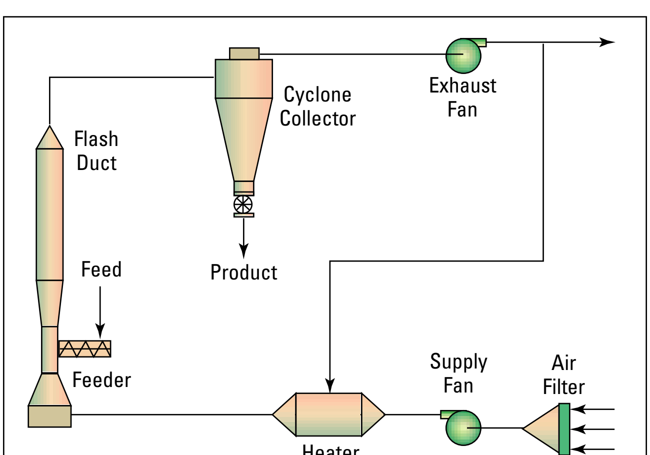


Figure 8. Partially recycling spent drying-air conserves heat.

Ensuring feed dispersion

Since the flash-drying process requires proper dispersal of the feed, if it is too wet or too sticky, adequate mixing cannot be accomplished. The simplest way to ensure proper dispersal is to use external back-mixing of some of the recycled, dried product (Figure 9), typically done in a paddle mixer. The ratio of fresh feed to recycle depends on the product to be dried. In this arrangement, some of the already dried product will pass through the flash dryer several times. This may be unacceptable for some products, but is suited for some starches and grains, as well as certain pigments.

To avoid having part of the product exposed to multiple passes, an agitated flash dryer may be used (Figure 10). The feed enters from an agitated feed tank (not shown) via a screw conveyor into the drying chamber, which contains a rotor/disintegrator. The rotor continuously exposes wet sur-

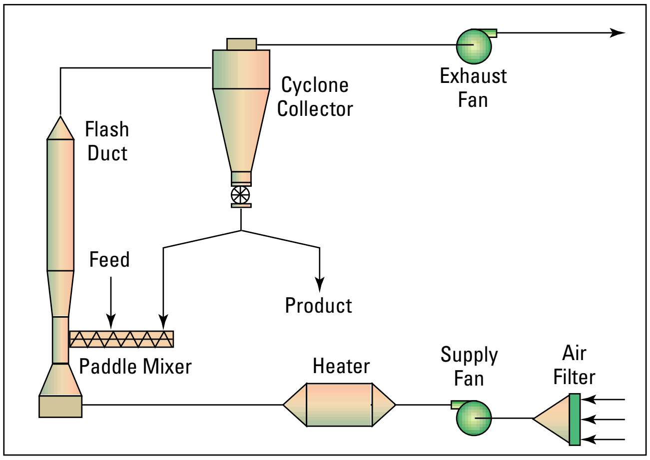


Figure 9. Back mixing ensures proper feed dispersion.

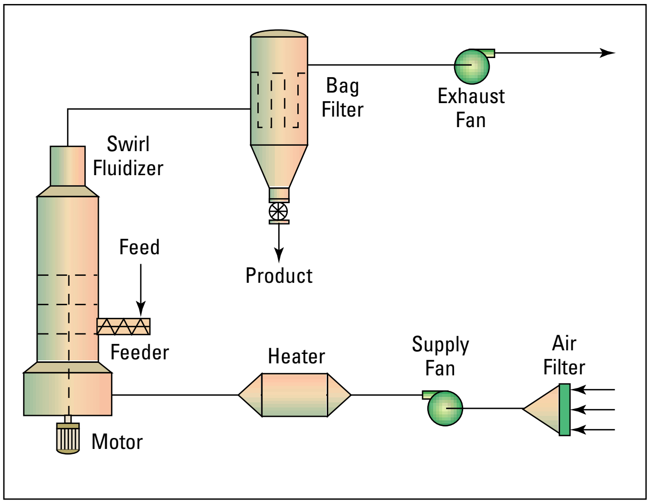


Figure 10. Agitated system for heat-sensitive feeds.

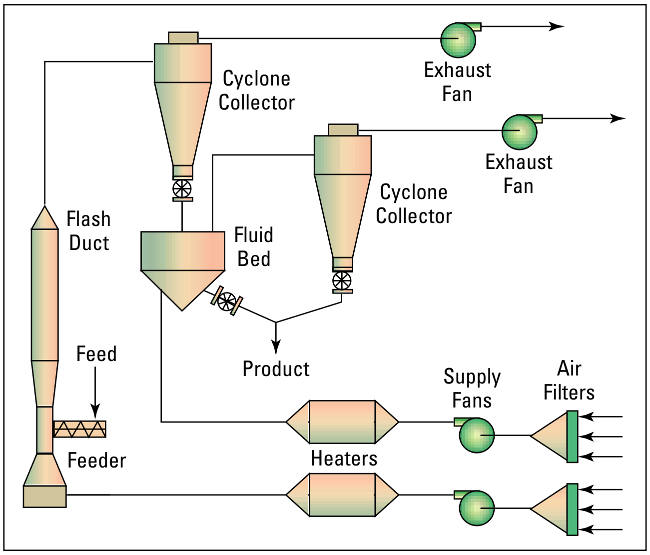


Figure 11. Flash and fluid-bed combination removes surface and bound moisture.

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faces to accommodate for the short residence time. This system is particularly useful for inorganic and organic pigments, as well as inorganic products such as kaolin and alumina.

Conveying vs. drying

The gas flow rate must be great enough to pneumatically convey the product, yet this gas provides the only heat input to the drying process. Typically, powder loads are < 1 lb solid/lb drying gas. The exception is a system containing an integral mill. Such systems are mostly used for low-moisture feeds when size reduction is emphasized more than drying.

When the gas flow required for conveying is greater than that needed for drying, other drying systems may be more applicable, such as fluid-bed or rotary types. This is particularly true when the average particle size is above 100 μm. Further, fluid-bed and rotary dryers have the advantage that part of the heat can be provided through heat panels or steam-tube bundles, improving the economy.

Pre-drying applications

The final use for flash drying is in combination systems, with flash drying as the first stage and a fluidized-bed dryer as the second (Figure 11). Again referring to Figure 1, flash drying removes the surface moisture, while the second stage offers a longer residence time to remove bound moisture. These systems are used for a wide range of polymers.

Process economics

As already mentioned, flash dryers are cost-effective, and the simple system requires the lowest capital investment. In general, adding the features that have been discussed will only increase the cost by 10–20%. The exception is for the two-stage systems, which are closer to 50%. Evaluating drying alternatives is complicated because many combination systems can be used, for instance, a ring dryer with external back-mixing and partial recycle; and the cost of these enhancements is cumulative. The choice of the upstream dewatering system is key, since the proper equipment will lower the feed's moisture and lessen the load and cost of the flash dryer. For example, dewatering efficiency can be increased by using a plate-and-frame filter press instead of a belt filter press. CEP

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