COMPARING HORIZONTAL AND VERTICAL DRYERS IN DYNAMIC DRYING

When considering whether to use a horizontal or vertical dryer for dynamic contact drying, there are a few aspects to consider. What material type are you using? Does your material have specific process parameters? Is your process a batch or continuous one? This article describes how horizontal and vertical contact dryers work and what material each dryer is best suited for.

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Vertical or horizontal dryers — which dryer is right for what type of task? Each dryer has its own advantages and disadvantages, as shown in Table I. Vertical dryers work well for batch processes, whereas horizontal dryers can manage batch and continuous processes. Also, both dryer types can handle a variety of materials. Ultimately, the decision of whether to use a horizontal or vertical dryer depends on your application's process and end product.

Before you decide on a vertical or horizontal dryer, you need to determine if you're going to use a stationary or dynamic contact drying process. In a *stationary* or *static dryer*, the material being dried remains still on a tray or conveyor belt while the drying takes place. Stationary dryers, such as industrial drying ovens, are good for drying highly fragile materials with shear forces. In a *dynamic contact dryer*, the material is continuously mixed with paddles or blades while being dried. Compared to traditional stationary dryers, which don't provide even heat distribution, dynamic contact dryers offer a number of advantages in both vertical and horizontal configurations. Increased process efficiency, the gentle handling of sensitive materials, and the elimination of temperature and humidity fluctuations make dynamic contact drying the method of choice for a variety of applications versus traditional stationary drying.

In industrial production processes, achieving a consistently high-quality material is of the utmost importance. Material quality may suffer during drying, especially if the temperature and humidity fluctuate over the course of the process. When your goal is to consistently and precisely maintain defined operating parameters during the drying process, dynamic drying is preferable to stationary drying.

Mixing while drying material

During contact drying, whether taking place in a horizontal or vertical dryer, as shown in Figure 1, the material being dried is continuously mixed with mixing instruments (such as blades or a helix) throughout the entire drying process. Because new particles are

TABLE I

A comparison of horizontal and vertical contact dryers.

	Horizontal	**Vertical**
Mode of operation	Continuous and batch	Batch
Applications	From powder to high-viscosity slurries and filter cakes	From liquids to free-flowing bulk materials
Advantages	High energy input and therefore increased potential drying capacities	Near complete material discharge and easy to clean Highly suitable for food and pharmaceutical requirements
Limitations	Difficult to completely empty and reduced cleanability	Can't operate in continuous processes

constantly contacting the heating elements, the heating surfaces are used to their maximum efficiency. As a result, the temperature of all the material contained in the dryer is gradually increased to the desired level without any sharp rises or drops in temperature, which can ultimately damage the material.

By mixing the material during the drying process so that the same material doesn't only touch one part of the heating elements, the material's temperature doesn't get too high or too low. This is a major advantage over stationary drying methods where the material's temperature has the tendency to rapidly increase or decrease due to limited contact with the heating element. Contact drying is especially useful when your application involves sensitive materials, such as spices, or materials that must reach a target temperature, such as with calcination processes. Additionally, since the materials are dynamically circulated, meaning the material doesn't stay stagnant or flow in a rigid pattern in the dryer, *dead zones* or areas of low material movement are avoided. This eliminates individual particles being heated to excess temperatures, which can lead to damaged material.

This same steady temperature change effect can also be applied to the dryer air's humidity level. Continuous material movement means that the material's temperature remains steady throughout the drying process as does the material's humidity level. This also means that the residual moisture content is consistent throughout the material, resulting in a reliable and high-quality end product. With consistent material temperature and moisture content levels, the drying process isn't only shorter than with stationary drying but also requires less energy. Contact drying leads to an increase in process efficiency, which conserves resources while ensuring a consistent material quality level.

A contact dryer can be used in drying and evaporation processes with various bulk materials. Whether a vertical or horizontal dryer design is more suitable for the respective application depends on the material and the material's process parameter requirements.

Drying material horizontally

A horizontal contact dryer constantly mixes the material being dried so that many different material particles touch the dryer's heating elements. The dryer has a horizontally oriented cylindrical mixing vessel. Within the vessel are mixing blades attached to arms on a centered shaft, as shown in Figure 2. The dryer unit and blades are heated by internal steam or thermal oil. The material enters the dryer's top inlet and is dried and moved simultaneously throughout the vessel body by the mixing blades. The moisture extracted from the dried material is removed through a vapor filter. When the material is done drying, it exits out the dryer's bottom outlet and is conveyed to the next step in the process.

The dryer blades' movement along with their arrangement allow for short material residence time within the unit as new material is constantly touching the heated mixing blades throughout the drying process. This leads to even material heating and drying and efficient energy use.

While the horizontal contact dryer, as shown in Figure 3, can be used for batch and continuous processes, it's best suited for continuous processes, such as egg yolk extraction. For example, if an upstream rotary pressure filter or indexing belt filter constantly

FIGURE 1

A horizontal contact dryer (left) is shown in comparison to a vertical contact dryer (right).

FIGURE 2

The horizontal dryer's operating principle makes it well-suited for continuous processes.

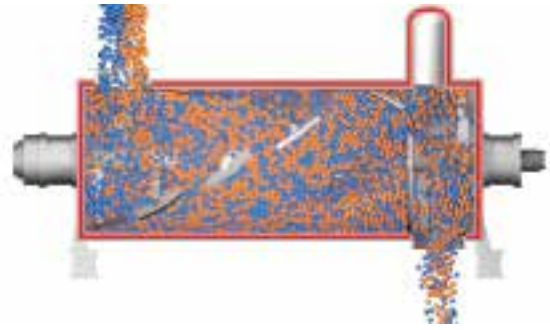

FIGURE 3

The horizontal contact dryer is designed for large quantities of material.

FIGURE 4

Mixer blades with a hard metal lining make the horizontal dryer highly durable and wear-resistant.

FIGURE 5

Because the vertical contact dryer empties from the bottom, hardly any particles are left behind, which is good for high-cost materials.

conveys bulk material containing residual humidity to the dryer, a continuously operated horizontal dryer can help ensure there are no disruptions to the continuous process. The continuously operated dryer allows the material to constantly flow into the dryer's top inlet, through the vessel, and out of the bottom's outlet without any breaks in time. However, horizontal dryers have other advantages regardless of how they are operated. Those advantages depend on what type of material is being dried within the horizontal dryer.

The horizontal dryer is advantageous to the material it's designed for, the material amount the dryer can process, and its energy level capabilities. The horizontal dryer is designed for coarse material that requires thorough mixing and efficient use of the heating surfaces. The dryer is appropriate for large quantities and complex bulk materials, ranging from powders (such as active pharmaceutical ingredients) to high-viscosity slurries (such as paint sludge) and filter cakes that are watery or contain solvents (such as flame retardants). The dryer's ability to handle a high energy load allows for drying capacities of up to 1,500 kilograms of water per hour. In the case of coarse material, a horizontal dryer can be designed for heavy-duty use, for example, by having its blades and blade arms welded on by using tungsten carbide, which is known for its density and stiffness. These special tungsten carbide-welded blades are shown in Figure 4.

Drying material vertically

A vertical contact dryer is similar to a horizontal contact dryer in that they both constantly mix the material being dried so that many different material particles come in contact with the dryer's heating elements. However, the vertical dryer unit stands upright and is a short cylindrical vessel with a conical bottom, as shown in Figure 5. Instead of mixing blades attached to arms on the dryer's inside, the vertical dryer uses a conical mixing helix attached to a centered shaft that rotates and gently mixes the material. The dryer walls are heated by internal steam or thermal oil. The material enters the dryer's top inlet and makes contact with the helix as the material flows downward by gravity to the dryer's bottom. The material is then mixed and dried as it's pushed upward along the dryer's heated walls back to the vessel's top by the mixing helix. This cycle continues until the material is done drying, at which point the material is discharged from the outlet at the dryer's conical bottom. The moisture extracted from the dried material is removed through a vapor filter.

The vertical dryer's principle of simultaneously mixing while drying the material allows for a higher-than-average heat-transfer coefficient to be achieved

compared to a vertical stationary dryer. The rotating mixing helix feeds the material upward along the heated container walls and then guides the material downward along the centered shaft of the mixing unit, ensuring maximum heating efficiency.

Unlike the horizontal dryer, the vertical dryer is only suited for batch processes and works especially well for applications involving small quantities of delicate or costly material. Many materials, especially in the food and pharmaceutical industries, need to be gently dried at low temperatures so that active ingredients or flavors aren't damaged or affected during the drying process. There are often strict material temperature specifications that have to be observed, including, for example, the maximum temperature a material may be exposed to and for how long.

In addition, the vertical dryer's bearings and seals are located outside the mixing chamber to minimize the potential risk of material contamination, which is especially important for pharmaceutical or food materials that are subject to strict hygienic standards. Also, the dryer's vertical setup, as shown in Figure 6, prevents a previous mixing process' material from contaminating the current batch. Because the dryer is emptied downward, the entire mixing chamber can be flushed and washed using nozzles, quickly cleaning the material residue from the unit. This means the dryer is thoroughly cleaned and ready to start with a new batch of a different material. Furthermore, some vertical dryers come with a lifting column, as shown in Figure 7, which allows the entire dryer to be opened with ease for an even deeper cleaning. Using a movable attachment on the lifting column, the column lifts the dryer's top so that the top separates from the dryer's cylindrical vessel and conical bottom. This enables an operator to have easy access to the dryer's interior and also helps to make the vertical setup a great choice for small quantities of alternating material groups.

If even a small quantity of a high-cost material, amounting to no more than a few percentages of an individual batch, remains inside the dryer, this will have a major financial impact over the long term. The vertical configuration of material being discharged

FIGURE 6

The vertical dryer is highly suitable for delicate materials.

FIGURE 7

A lifting column helps to quickly and completely clean a vertical dryer.

from the dryer's bottom outlet helps with material yield and profit.

Testing new applications

The decision of whether to use a vertical or horizontal contact dryer is made based on various material and process requirements. When choosing the appropriate dryer for your application, be sure to speak with a dryer manufacturing expert, who can provide their experience in different application areas. If a brand-new application is planned, some dryer manufacturers will allow potential customers to use their test centers to carry out design tests with the respective material as well as a detailed analysis of the drying characteristics. This makes selecting and configuring the right system beforehand possible, helping to make a much safer investment for the customer. **PBE**

For further reading

Find more information on this topic in articles listed under "Drying" in the article archive on *PBE*'s website, www.powderbulk.com.

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