For many years, clients have asked the question, “How can I get more capacity out of my dryer?” Let’s revisit a past column that discusses seven options to add drying capacity. But first, we’ll review some drying basics.

Drying basics
In bulk solids drying, heat is transferred from a heat source to a wet bulk material. Dryers use one of three methods to transfer heat: convection, conduction, or radiation. In a convection dryer (including flash, hopper, rotary, spray, tunnel, fluid-bed, and other dryers), the heat source (hot gas) directly contacts the wet material and carries away the evaporated moisture. In a conduction dryer (including drum, paddle, disc, thermal-screw, steam-tube rotary, and other dryers), a metal wall separates the heat source (hot gas, steam, hot water, or hot oil) from the wet material, so that the heat source indirectly contacts the material. The heat is transferred (conducted) to the material through the wall, and a gas stream (not the heat source) sweeps away the vaporized moisture. In a radiation dryer (including infrared, radio-frequency, or microwave energy to create heat within the wet material), resulting in moisture diffusion and evaporation. As in a conduction dryer, a gas stream carries away the vaporized moisture.

The drying process has two principal zones or stages called the constant-rate zone and the falling-rate zone. The constant-rate zone ends at the critical moisture level, when the drying rate slows and the falling-rate zone begins.

Drying in the constant-rate zone is heat-transfer-controlled. That is, moisture evaporation occurs as rapidly as heat can be supplied to the wet material. Surface moisture is evaporated, as well as internal moisture, so long as the particle’s internal moisture-diffusion rate is greater than or equal to the surface-evaporation rate. As long as the drying gas doesn’t become saturated, the gas’s relative humidity (dew point) isn’t a significant factor during constant-rate drying.

At the critical moisture level, the surface moisture has mostly evaporated, but internal moisture remains and must be removed during falling-rate drying, which is diffusion-rate limited. As the material temperature increases, the moisture-diffusion rate increases, thereby reducing the necessary residence time in the dryer. The driving force for drying during this stage is the partial pressure differential — that is, the difference between the particle’s internal
moisture vapor pressure and the partial pressure of the moisture in the surrounding drying gas. In this stage the drying gas’s relative humidity can become a significant factor, affecting the final moisture content you can achieve.

Using data from laboratory bench-scale tests, the two zones and the critical moisture level can be plotted, as shown in Figure 1. In the figure, the blue line (the drying curve) plots the material’s changing moisture content (pounds of moisture per pound of dry solids) over the drying time. The red line plots the material temperature during the same period.

Typically, during constant-rate drying, the blue line will be nearly straight, descending from the material’s initial moisture level down to the critical moisture level. This is because the particle surfaces are moisture-saturated, so the drying proceeds at a constant rate. After the material reaches the critical moisture level, the particles no longer have a saturated surface, so the drying rate now depends on moisture diffusion to the surface for further evaporation. That’s why the drying curve’s slope is no longer a straight line; it shows the continuously decreasing drying rate during falling-rate drying.

During constant-rate drying, the material temperature remains nearly constant at the wet bulb temperature of the drying gas. As falling-rate drying progresses, the material temperature


Now, let’s look at some ways to improve your dryer’s production capacity.

**Increasing capacity during constant-rate drying**

1. Since temperature differential (between the heat source and the material) is the driving force for heat transfer in the constant-rate zone, consider using a higher heat-source temperature. Caution: Keep in mind your material’s temperature limitations — if it gets too hot, will it case-harden, soften, stick, melt, or degrade?

2. Once you’ve maximized the heat-source temperature, the next step is to decrease heat-transfer-resistance factors. In a convection dryer, you can reduce heat-transfer resistance by increasing the contact efficiency between the gas and the wet material. Gas flow through the material bed is more effective than a gas sweep across the material bed’s surface. If you can also increase the relative velocity between the gas and the material, you’ll further reduce the resistance.

   The relative velocity also reduces heat-transfer resistance in a convection dryer. The greater the relative velocity across the heat-transfer surface, the lower the heat-transfer resistance at the heating surface. In addition, the greater the mixing turbulence in the material bed, the less the resistance to heat transfer from particles migrating from the heat-transfer surface into the bulk mass of material.
Creating drying zones and multiple stages

6 You may be able to increase your dryer’s production capacity by segregating the two drying zones in the drying chamber. Fluid-bed dryers, belt-conveyor dryers, and hopper dryers (to some extent) can often be zoned. If you zone your drying chamber, you can increase the constant-rate evaporation capacity by using a higher inlet gas temperature without necessarily increasing the drying gas flowrate. Then, in the subsequent falling-rate zone, you may be able to use a smaller quantity of low-dew-point drying gas. By chamber-zoning, you can shift the bulk of the evaporative load to the constant-rate zone and gain additional residence time at a higher material temperature in the falling-rate zone, which will also speed diffusion drying.

A word about costs

Of course, adding an additional independent dryer line will always provide extra capacity — but at a price! Before spending this kind of money, it may be worthwhile to perform a process-performance audit of your existing dryer operation, develop drying curves from bench-scale tests, determine your material’s temperature sensitivity, and define process design limitations for your existing gas-handling equipment, including such components as blowers, fans, heaters, cyclones, scrubbers, bag filters, and so forth. You may be surprised at how much money you can save by increasing your dryer production capacity.

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