HOW TO JUSTIFY MULTIPLE ZONE DRYERS

Q: Are multiple zones really necessary in my new dryer, or are they an expensive frill?

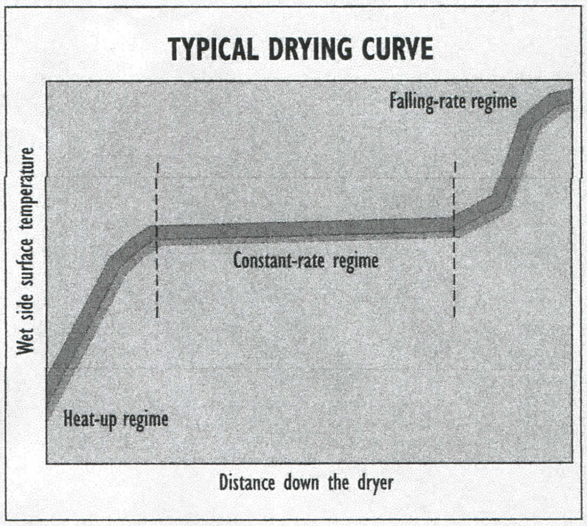
A: You can probably get by with two or three zones—if you don't mind buying a longer or slower dryer than you really need, and you never *plan to change coating speed, coating* thickness, solids concentration, or coating formulation. In other words, if your drying needs may change during the life of the coater, then at least five or six independently controlled zones can save a bundle in operating costs.

Independently controlled zone

An independently controlled dryer zone is a portion of the dryer in which the impingement air velocity, temperature, and solvent concentration can be maintained within a practical operating range without significantly limiting, or being limited by, the adjacent zones.

Fully independent zones require separate controls, fans, ducts, heating/cooling units, and makeup/recycle dampers. Partially independent zones may share a common fan and header, but typically control air velocity and temperature with separate dampers and separate heating/cooling units.

Even fully independent zones dynamically interact, because when conditions in a zone are changed, the downstream zones are affected by the change in the wet substrate. Control actions in the downstream zones compensate for the changes in those upstream.



The drying curve

A typical drying curve is a plot of wet-side surface temperature vs. distance down the dryer. It is divided into three regimes: heat-up, constant-rate and falling-rate.

Coated substrate starts heating immediately as it enters the heat-up regime of an impingement or a flotation dryer. The substrate usually absorbs most of the heat, and the wet surface temperature rises sharply until solvent evaporation *starts absorbing about as much heat as* the substrate. In the constant-rate regime, heat is absorbed primarily by freely evaporating solvent at, or just above, the wet-bulb temperature. In the falling-rate regime, diffusion starts limiting the solvent evaporation rate and the substrate again absorbs most of the heat. Surface temperature rises sharply until it approaches the impingement air temperature.

Independent zones help

Maximizing air temperatures and velocities minimizes dryer length and/or maximizes speed. Unfortunately, there are inevitable temperature limits beyond which the coating and substrate will be damaged, and high air velocity can upset a wet mobile coating. With too few independent zones, temperature and air velocity limits that are valid in one part of the dryer limit the performance of the rest of the dryer. The user is therefore stuck with an unnecessarily long or slow dryer. There are many examples of these unnecessary limits.

Dilute and mobile fresh coatings are easily damaged by moving air which causes streaks, chatter, mottle, etc. But, as coatings dry, viscosity increases, the coatings immobilize, and resistance to damage by moving air increases. Limiting air velocity to what is acceptable at *the dryer entrance degrades downstream* dryer performance, where the coatings are more robust.

As drying progresses through the constant-rate and falling-rate regimes, evaporative cooling decreases and the maximum tolerable air temperature decreases. Limiting the upstream dryer sections to temperatures acceptable near the exit again degrades dryer performance.

Solvent coatings often encounter a nasty problem called skinning, where a layer of the coating near the air interface dries too early, forms a skin, and severely retards evaporation of solvent below the surface. To avoid skinning, operators often slow drying in the constant-rate and heat-up regimes by raising the solvent concentration in the air. However, high impingement air solvent concentration at the end of the constant-rate and in the falling rate regime—where users are trying to drive out the last vestiges of the solvent—severely degrades dryer performance.

Finally, we can minimize the zones quired in a dryer dedicated to a specific coating by meticulously fitting the zones to the drying curve for that coating, minimizing investment. But what happens if we need to speed up the coater, or change the coating thickness or formulation? The dryer we so frugally designed no longer fits the air velocity and temperature profile the new drying process requires, *and our investment* savings are consumed by higher operating costs.