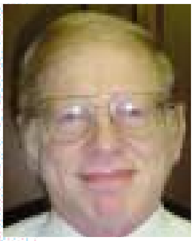
MIXING MECHANICS



Peter R. Holman

Improving blend uniformity by controlling particle size

One of the biggest causes of nonuniform powder blends is a wide difference in the ingredients' particle size distribution. If the ingredients' particle sizes are widely distributed, the particles can segregate regardless of your mixer type. It happens with rotating shell units, such as V-blenders and double-cone mixers, and stationary shell units, such as ribbon and plow blenders. When a blend's particles have uniform size or a very narrow size range, segregation is rarely an issue. In this column I'll explore the segregation that takes place both in the mixer and during or following discharge and how you can prevent it.

When segregation occurs

As a general rule, you're more likely to run into segregation problems if your powder blend is free-flowing. If your powder blend flows with difficulty, then it probably won't segregate. This is because the cohesive forces that make the blend balky hold the particles together, preventing segregation.

Particle size makes a difference — smaller particles are more cohesive. A blend made up of particles over 75 microns will segregate readily. A blend with particles between 10 and 75 microns will commonly segregate. But a blend with particles under 10 microns will segregate very little.

When a blend contains ingredients with both large and small particles, segregation can be avoided if the small particles cling to the large particles. If this doesn't happen, the particles will segregate when you discharge the blend into a storage hopper or drum, for example. Vibration during shipping can also cause segregation.

Particle shape and density also affect segregation, but these are generally minor factors compared with particle size.

Common segregation mechanisms

Common segregation mechanisms are trajectory segregation, percolation, rise of coarse particles during vibration, and elutriation segregation. All of these mechanisms depend on particle size distribution.

Trajectory segregation. Trajectory segregation occurs when particles are propelled with a horizontal velocity, such as in a ribbon blender. Stokes law tells us that a particle with twice the diameter will travel four times the distance:

$$\text{Particle velocity} = \frac{v_o \rho_s D^2}{18\eta}$$

where v_o is the initial velocity, ρ_s is the particle density, D is the particle size, and η is the fluid viscosity. Thus, if you have two particles with the same density and fluid viscosity but different sizes, the larger particle will move proportionally faster and farther in the same amount of time. This tells us that when a blend with big and small particles is moving, the larger particles are going to go farther and faster than the small particles, resulting in segregation.

Percolation. Percolation occurs when smaller particles pass through the voids between larger particles. Percolation can happen any time particles are disturbed, such as when they're shaken, stirred, or vibrated during discharge into another vessel or during truck transportation.

Rise of coarse particles during vibration. When a blend with a wide particle size distribution is vibrated, the larger particles move to the surface and the smaller particles drop to the bottom.

Elutriation segregation. Elutriation segregation occurs when an ingredient is dumped from a mixer. The large particles displace the air and go to the vessel's bottom. The air moves up vertically, taking along the fines whose terminal velocity is slower than the upward airflow. The result is a cloud of fines that settles on the blend's top. When the vessel is discharged, a slug of fines comes out at the end.

Preventing segregation

Clearly, a blend made up of ingredients with widely different particle sizes is going to be subject to several segregation mechanisms. But if all your ingredients have close to the same particle size distribution, your blend is less likely to segregate.

So how can you ensure that the ingredients in your blend have particle sizes that will form a uniform blend without segregating? There are several things you can do, both before and after blending, to accomplish this goal.

Raw material specifications. When was the last time you looked at your ingredients' average particle size and particle size distribution? If the ingredients are segregating in the mixer, you may have to change your specifications. Talk to your suppliers; they want to give you what you want. You can request that the ingredients you buy are within a specified particle size range. There may be a cost difference, so you'll have to evaluate whether an improved blend is worth the extra cost.

Pregrind. If your supplier won't or can't supply ingredients with the correct particle size distribution for your blend, you can grind them yourself. You may need to grind one or several ingredients. It's sometimes easier and less costly to preblend several ingredients and grind them together. You can then add the pregrind to the rest of the ingredients in the mixer.

You have to consider the economics of pregrinding, including additional equipment, space, and labor you might need, as well as the additional processing time. Will the improved blend quality and uniformity be worth it? Keep in mind that with improved quality, your sales will likely increase and you may be able to charge a higher price for your blend.

Postgrind. The idea of mixing is to achieve a good blend. If you have a good blend in the mixer but it separates during or after discharge, you don't have a good blend. Your mixer can only go so far. Sometimes to get a good mix you have to act outside the box and make corrections after the blend leaves the mixer. For example, you may have to postgrind the blend.

If you postgrind, keep close tabs on the blend quality because particles with different characteristics may feed to the grinder at different rates, and they *will* reduce at different rates. For example, softer particles may reduce much more quickly than hard particles.

You may also discover that you need to do a postblend after the postgrind. As with pregrinding, don't forget to consider the processing economics. Will the results be worth the extra time and money?

The proof is in the blend

If you decide to make some of the changes suggested here to prevent segregation, you can demonstrate improvement by sampling your blend before and after you make the changes. Remember that the sample size is important. If you're making vitamin pills to be taken once a day, the sample size should be the same size as the pill or tablet to determine if all the ingredients are present in each dose. If the blend will be used for products in 1-pound bags, then take 1-pound samples. **PBE**

Peter R. Holman, *PE, is a consulting engineer specializing in engineering and designing mixing systems. He has more than 25 years experience developing mixing systems for the chemical, pharmaceutical, cosmetics, biotech, and food industries. He leads mixing seminars at the College of Engineering, Professional Development, University of Wisconsin-Madison, and is the author of a book on mixing. He holds a BS in chemical engineering from the University of Wisconsin-Madison.*

"Mixing Mechanics" appears in *Powder and Bulk Engineering* twice a year. The author will answer your questions in future columns. Direct questions to him at 262-763-3373 (pholman @wi.rr.com) or via the Editor, PBE, 1155 Northland Drive, St. Paul, MN 55120; fax 651-287-5650 (toneill@cscpub.com).