Mix Small, Think Big: Practical Tips for Mixing Scale-Up

Successful scale-up of specialty industrial mixing equipment relies less on straightforward formulas and more on empirical data and experience.

BY CHRISTINE BANASZEK, SALES MANAGER, CHARLES ROSS & SON CO.

Scaling up from a laboratory or pilot plant mixing operation requires that the physical and chemical properties of the product are duplicated at the full-scale production level. The process further requires that the desired outcome is produced within a reasonable amount of time. Here we list practical tips worth considering before and during the scale-up phase of any batch mixing operation.

Choose Scalable Laboratory and Pilot Plant Mixers

Avoiding product lines that do not offer a clear scale-up path reduces the risk of roadblocks in the future when it's time to increase production.

Maintain Tip Speed and Agitator Geometry

Always account for longer mixing and heating times due to the decrease in surface area-to-volume ratio and/or horsepower per unit volume.

Closely Simulate Actual Conditions

Perform mixer testing using your own raw materials and simulate actual oper-

One-quart double planetary mixer.

ating conditions as closely as possible. Well-equipped manufacturers offer testing services supervised by a mixing expert. Renting equipment for in-house trials at your facility is another option. To obtain reliable data for scale-up, a good rule of thumb is to test on a mixer that is no smaller than 10% of the capacity you are looking to scale up to.

Quantity Matters

Determine the quantity of full and partial batches that can be made on a particular mixer model to accommodate fluctuations in product demand.

Explore a "Change-Can" Design

Scaling up to a larger mixer with a "change-can" design can further increase throughput and equipment utilization by enabling semi-continuous processing. In other words, a single mixer may be supplied with multiple interchangeable vessels that cycle through a sequence of charging, mixing, discharging and cleaning.

Consider Alternative Mixer Technologies

If scale-up calculations point to a prohibitively large mixer size, consider alternative mixer technologies that can potentially supplement or even replace your current mixing procedure yet accomplish the same end point. Examples include switching from a saw-tooth disperser to a rotor/stator mixer to improve dissolution rates, installing a solids induction system to accelerate powder wet-out and dispersion, or using an ultra-high-shear mixer to finish emulsions faster than a traditional rotor/stator. Depending on the specifics of your particular application, some of these alternative solutions could reduce cycle time, so you can work with more manageable batch sizes and still achieve the desired output volume per day or shift.

Seek Help When Needed

Partner with a supplier that has extensive experience in specialty mixing. Even in ideal circumstances, scale-up will require some degree of tweaking to optimize your process in a larger volume.

Laboratory mixer with high shear rotor/stator attachment.

Laboratory triple-shaft mixer.

Scalable R&D Mixers

Developing a new formulation at the R&D stage can require multiple iterations to arrive at the optimal quality, functionality, cost or a combination of these and other factors. Typically, mixing at this scale is relatively easy to accomplish. Blade size and agitator power are easily oversized in a benchtop setting, and any heat transfer or chemical reaction that accompanies the mixing step is completed relatively quickly.

While various kinds of R&D mixers are readily available—including magnetic stirrers and kitchen-type single planetary mixers or high speed blenders—many of these devices are not scalable equipment and will require extra time and resources for experimentation once the product graduates to pilot or production scale. Following are some examples of truly scalable laboratory specialty mixers.

Double Planetary Mixers

The double planetary mixer (DPM) moves material by rotating two identical blades on their own axes as they orbit on a common axis. The blades continuously advance along the periphery of the mix vessel, removing material from the walls and transporting it toward the interior.

Portable 1-cu ft ribbon blender.

DPMs are ideal for mixing thick gels, viscous pastes and dough-like materials. They are also used for vacuum-drying pastes or slurries into free-flowing powders. Half-pint models are available, and these can handle batches as little as approximately 100 ml.

High-Shear Mixers

Bench-top high-shear mixers can process batch volumes as low as 1 l using interchangeable rotor/stator heads, sawtooth dispersers and propeller blades. A special micro-rotor/stator attachment is designed for even smaller batches in the range of 50-500 ml. Laboratory inline rotor/stators are also available.

Multi-Shaft Mixers

Multi-shaft mixers consist of two or three independently driven agitators working in tandem. A high-speed disperser quickly draws powders into the liquid batch through a powerful vortex. The rotor/stator carries out a number of tasks depending on the product being mixed (i.e., it can puree solid ingredients, break down agglomerates, or prepare fine droplets in an emulsion). Finally, a low-speed anchor promotes bulk flow and uniform batch temperature while scraping the vessel sidewalls and bottom.

> Multi-shaft mixers consist of two or three independently driven agitators working in tandem.

Working capacities of multi-shaft lab mixers start from around 0.5 to 0.75 gal. These units are highly versatile, not only in the range of agitation conditions but also the variety of applications they can handle (from thin slurries and solutions to viscous pastes and suspensions). For even higher viscosities (> 500,000 cP), "hybrid" planetary mixers are used. In these mixers, the high-speed disperser rotates around the vessel, instead of having a fixed axis of rotation, and is complemented by a planetary stirrer.

Ribbon Blenders

Ribbon blenders are commonly used for straightforward dry blending (solid-solid) applications. The classic design features a U-shaped horizontal trough and an agitator made up of inner and outer helical ribbons that are pitched to move material axially in opposite directions, as well as radially. A 0.5-cu ft ribbon blender model has a 0.5-cu ft working capacity and can accommodate batches as small as 2 gal. **Ci**

For more information, contact the author at (631) 234-0500 or cbanaszek@mixers.com, or visit www.mixers.com.