



New High Speed Mixer Designs Allow More Efficient Development and Scale-Up

Work in a typical lab is aimed at achieving a long list of goals in product development. But every aspect of business in the lab is also driven by a collection of chronic shortages. Space for equipment in the lab is always tight, and virtually every lab manager will tell you that his lab is under-funded.

During the last few years, new directions in product development have added to the challenge of managing R&D. The drive to reduce VOCs, both with waterborne formulations and with formulations that require lower solvent content, has introduced many new variables in raw materials, special-purpose additives, mixing/dispersion equipment, and process techniques that must be considered in developing new products. In this environment, any equipment that provides a boost in versatility and efficiency, and enables development engineers to be more productive, is a welcome improvement. A single machine that can do the work of two, three or even four machines can save space in the lab and cut operating costs sharply.

When a piece of equipment provides the tools necessary to quickly compare the advantages of competing mixing techniques — using a method that is controlled, quantifiable, and projectable for scale-up — its value is far greater. It allows the development engineer to combine two dimensions of laboratory testing and development: to refine the formulation and identify the optimal process for a new product.

Rotor/Stator or High-Speed Disperser: Which is best for your needs?

Many manufacturers have found that they can no longer safely presume that a traditional high-speed disperser (HSD) is the best way to make contemporary products. The rules have changed. Many have found, for example, that some processes require the higher

shear of a rotor/stator mixer to achieve a product with the desired properties — such as droplet size, stability, agglomerate size and color development. Often products are vulnerable to air entrainment, and the familiar vortex created by the HSD can cause serious foaming problems. To reduce the foam, formulators can add a defoaming agent, which adds cost and can also affect other properties - requiring more time and perhaps other additives. In such situations, switching to a reverse vortex rotor/stator mixer can avert the problem.

Compared to the HSD, the rotor/stator mixer generates an inverted vortex and much less surface violence, sharply reducing the air entrained in the batch. In the manufacturing of many products, manufacturers have learned that a high-speed rotor/stator mixer can outperform an HSD by a wide margin, saving time and producing an end product with superior product qualities. When milling is required, the rotor/stator mixer can produce a better pre-mix which often leads to a better end product coming out of the mill. Incidentally, in many applications a superior pre-mix can also allow a product to be completed with fewer passes through a mill. For companies that are looking for ways to increase capacity without committing much capital to plant equipment, this is an extremely efficient answer.

Base Your Choice on Solid Test Results

The reality in many labs today is that engineers must consider both high-speed dispersers and rotor/stator mixers in development to ensure that they identify the optimal process for their new product. Since most plants have many HSDs on the floor, there is a strong temptation to rely on this equipment during lab development. That's the "*Don't rock the boat*" strategy, and it may seem to make sense when the budget is tight for new equipment. But it's very dangerous if you have competitors who are determined to find a new advantage in either product quality or cost.

Equipment manufacturers must recognize this shift and respond with new equipment designed to make comparative testing efficient, fast, and reliable. Over the years, a few dispersers have allowed operators to switch from a disperser blade to a rotor/stator, but

the process was usually difficult, messy and time-consuming (which translates to downtime for the machine and an engineer). A new approach to equipment engineering can eliminate those obstacles. The key is to base the engineering on what is truly needed in the modern laboratory rather than on outdated design presumptions.

Following are two important factors to consider.

- **Agitators must be easily interchangeable**

Any agitator change that requires more than a few minutes is too slow. If it requires specialized tools, it is too complicated. If it causes a mess with exposed bearings, seals and shaft replacements, it has no place in the lab. The answer is to design the agitators specifically for fast interchange with no need to touch the bearing assembly or the shaft. Purchase lab development equipment that allows you to bolt on a variety of agitators certainly saves space in the lab. By doing double- or triple-duty, it allows you to eliminate something else in the lab, and that's always a plus.

- **Process comparability**

New push-button variable-speed drive technology makes changing speeds and the entire process much easier, faster and safer. Digital readouts and timers permit accurate, direct comparisons of several agitators while you fine-tune your process.

Scale-up considerations

Sooner or later, all new products have to leave the lab and go into production. Sometimes the scale-up process is smooth, sometimes painfully slow and costly, especially when product quality is closely controlled and there is little tolerance for off-spec quality. Usually it falls somewhere in between where it still offers an excellent opportunity to trim costs and get production online more quickly. Predictable, efficient scale-up can save a terrific number of work hours and cut unnecessary costs. There is an industry collection of “rules of thumb” used in the scale-up process.

- **Tip speeds** — A high-speed disperser generally runs at 5,000 fpm, a rotor/stator mixer at 3,700 fpm.

- Agitator location — A high-speed disperser is usually positioned 1/2 blade diameter from the bottom of the vessel and 1.5 diameters from the surface. The blade is usually one-third the diameter of the tank. Positioning for the rotor/stator mixer is quite different than for an HSD. A rotor/stator mixer can be located just about anywhere in the tank and in fact this highlights a common misconception about the operation of rotor/stator mixers. Operators who are accustomed to working with an HSD often look for a vortex that resembles the vortex created by an HSD. But the reverse-vortex rotor/stator is designed to generate an inverted vortex, which produces much less surface turbulence. This is one of the rotor/stator mixer's greatest advantages.

New Design in Mixing/Dispersion Equipment

In-line rotor/stator mixers have also been adopted for many applications, often supplementing high-speed dispersers (HSDs) instead of replacing them. For example, the in-line rotor/stator mixer provides a fast method to regrind products that are made with an HSD. Due to normal variation in raw materials, virtually any dispersed product may occasionally fail to meet the spec. By running a product through an in-line rotor/stator mixer, the manufacturer is guaranteed that only on-spec material proceeds on in the process. In-line mixers can also reduce problems caused by settling during transfer. Settling is a notorious cause of problems during transfer from bulk storage to a dispersion tank. A small in-line rotor/stator mixer can eliminate these problems by re-dispersing the raw material en route to the dispersion tank.

Bending the Industry Rules of Thumb

General guidelines for mixer/disperser set-up are useful because they provide a starting point. But to optimize operation, it's equally important to recognize the limitations of these rules and to refine the process with a much bigger set of variables in mind.

In general, the key parameters to focus on during the scale-up process include the following.

- Shaft speed and agitator tip speed (which is itself a function of agitator diameter and rpm)

- Variables in agitator design, such as the rotor blade height and rotor/stator clearance in the rotor/stator generator
- Horsepower
- Agitator location in the mix vessel
- Batch turnover rate, or flow rate, in the case of in-line rotor/stator mixers
- Heat sensitivity of the raw materials
- Flow pattern to promote efficient circulation, complete batch turnover, optimal particle size reduction and the dispersion of heat created by the agitator
- Viscosity
- Vessel size, aspect ratio, and range of working volumes for full and partial batches

The general relationships reflected in our mixing “Rules of Thumb” begin to lose their straight-line predictability when batch sizes get very large. Horsepower requirements, blade diameters and shaft lengths eventually become impractical or uneconomical. At this point, the equipment manufacturer must shift gears and consider additional agitators such as a slow-speed anchor that promotes additional flow and prevents dead spots along the vessel wall. They can also consider using a small in-line mixer instead of a very large batch mixer. One of the great virtues of an in-line rotor/stator mixer is that it can handle an extremely large batch with much lower horsepower, and with predictable batch turnover. New devices for high-speed induction of solids and liquids can also be added to precisely control and accelerate the process of mixing solid/liquid additions.

How to Select an Equipment Manufacturer

Your best insurance for efficient scale-up is to select a mixer/disperser product line that is intelligently designed to facilitate scale-up with operating parameters that logically relate each product model to the others in the line. By avoiding product lines that do not offer a clear scale-up path, you can significantly reduce the risk of roadblocks in the future when it's time to increase production. The next thing to look for is extensive experience in scale-up engineering, because even in ideal circumstances scale-up engineering will require some degree of tweaking to optimize your process in a larger volume than you are working with now. Finally, you should recognize from the start that the best way to

determine the right combination of agitators for your application, and the best way to use them, is to test a variety of equipment. Select an equipment manufacturer with a well-equipped laboratory and trial rentals for testing prior to purchase. The supplier's lab should include analytical facilities to quantify results between tests and modify subsequent testing as needed to zero in on the optimal mixing equipment and technique.

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