Mixer Selection for Paints and Coatings – An alternative consideration!

Part 1: Agitators, Blenders, High-speed Dispersers and Rotor/Stator Mixers

Each month I speak with dozens of experienced paint, ink and coatings manufacturers. They are experts in the chemistry of their product formulations and the dynamics of producing them. They understand every nuance of color development. They can predict the effect of a subtle change at any step in their process. Yet, when we speak of mixing equipment, we invariably go right back to basics.

> *"What equipment options are available now for low-shear let down?"*
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> *"What rotor size, tip speed, and horsepower are now considered reasonable for high-shear pre-mixing?"*
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> *"When do tank/batch size and viscosity require a switch from a single-shaft high-shear mixer to a multi-agitator mixer in order to prevent excessive heat build-up…?"*

Most agree that a periodic review of the basics in mixer design is valuable, at least to make sure that their process lines are still competitive. Technology is evolving quickly in many categories of mixing equipment, and a quick review of the "new" fundamentals may reveal that last year's workhorse in your mixing operation is now obsolete.

A cookbook-style review can certainly be useful, but it can also be deceiving. It places equipment like high-speed dispersers and rotor/stator pre-mixers in neat categories, and that is not the way the real world works. Mixer selection is just not that simple.

It's a balancing act. We balance the need for shear against the need for pumping action and sufficient flow to disperse the heat created by a high-shear device. We trade horsepower for greater agitator and tank diameters.

We also weigh one mixing device against another, and that is where mixer selection relies on experience and intuition. The real question is not which mixer is an obvious fit for your particular application, but where is the boundary that separates the usefulness of one mixer (or one *combination* of mixing devices) with that of another. Those boundaries are constantly moving as various technologies evolve, offering you opportunities to cross over, make a *fundamental* change in your mixing equipment and collect a huge gain in efficiency. What are the parameters (viscosity, heat-sensitivity, shear-sensitivity…) that point you toward one mixing device or another, and which of those conditions can be changed to allow you to adopt more advanced technology?

Focus on the big picture – and the big rewards.

Start with this update on the current uses for the most familiar types of mixing equipment, and on the key issues influencing their specification. This road map will help you find the most likely type of equipment for some applications.

Next, take a look at your process line through a wide-angle lens. If you are using a high-speed disperser as a pre-mixer now, and you go looking for improvements in HSD blade design, you'll never gain more than a modest improvement in production. But if you stand back and see that the HSD is just one component in a pre-mix/milling operation. By switching to a high-speed rotor/stator pre-mixer you can probably shorten the pre-mix process…*and shorten the milling process as well.* The savings in time, energy and labor on both ends of the line can be substantial – if you are willing to look at the mixing/milling process from a broader perspective.

Finally, you must recognize the necessity for analytical testing. Especially when you are considering a new combination of mixing devices, laboratory testing is critical. Quantitative results allow you to experiment creatively. Try a variety of equipment combinations. Later on, they enable you to fine-tune your mixing technique to optimize your process-line efficiency before the equipment is actually installed on your process line.

Blenders and agitators

These low-speed, low-shear devices are used to blend fluid products or to keep unstable fluid products in suspension. Blenders operate at low speeds, at tip speeds from 400 to 1600 fpm (feet per minute) with blades/impellers up to about half the vessel diameter. Agitators provide more aggressive mixing action, running at tip speeds from 1000 to 2500 fpm, with blades typically 1/3 the diameter of the vessel.

Both blenders and agitators are appropriate for products that do not require further development • such as particle size reduction or color enhancement. They are often used in large storage or let down tanks. Capacities of 1000-10,000 gallons are typical. Especially in larger tanks, multiple blades (or impellers) are often used to intensify mixing action or create opposing fluid flow.

Common uses include:

Let down • the final stage of production, in which the concentrated dispersion is mixed with other fluids to reduce the concentration and match the viscosity to the final product specification prior to packaging.

Recirculation • an interim stage, in which we maintain an unstable batch in fairly uniform suspension. The goal is to prevent settling while waiting for the next step in the process, or while feeding the next process step, such as a media mill or in-line mixer. Since a mill base or pre-mix (pre-dispersion) is normally a concentrated mixture, these usually involve batch sizes of 1,000 gallons or less. Speeds and vortexing are kept to a minimum to lower the risk of entrapping air while preventing stratification and settling.

High-speed dispersers (dissolvers)

Once considered state of the art in high shear mixing technology, the HSD (high-speed disperser) is a familiar sight in plants across the country. But these days it plays a minor role on most process lines. It is seldom capable of more than pre-mixing (inclusion), and it generally cannot produce what we accept as a "colloidal dispersion" today. (In practical terms, the particles in a colloidal dispersion are suspended and the stability of the dispersion is unaffected by gravity • the particles will not settle or separate.) High-quality dispersions are now made with finer-grinding machines, such as media mills, high-speed rotor/stator mixers, and three-roll mills.

The HSD is usually used as a pre-mixer. Its task is to incorporate powders in fluid components, and to prepare a mixture that can be fed into a media mill. Yet, a few applications remain for the HSD as a primary mixer. Latex house paints and primers, for example, are often made today with an HSD, without any need for further mixing or milling downstream. These dispersions do not require particularly small agglomerates, and they usually measure 3-6 on the Hegman gauge.

The problem is that the HSD is a high shear device that delivers limited pumping action. Other high-shear alternatives (such as rotor/stator mixers) now offer greater shear rates and at least similar flow. A few offer both superior flow and greater shear. This has confined the HSD to applications in which equipment must be low-priced and longer mixing cycles are acceptable.

The pre-mixing paradox.

If the HSD is inherently inefficient, why is it used so often in pre-mixing? Manufacturers assumed that bigger improvements were possible at other stages in the mixing/milling process. Few even bothered to measure pre-mix quality on the Hegman gauge, because they presumed that the real work would be done in the mill.

Indeed, pre-mixing has only recently become the focus of aggressive development. Mills and media have been in the spotlight for years, with technology advancing at a fast pace. But when development there finally leveled off, equipment makers were forced to look upstream for opportunities to improve the overall process.

Pre-mixing was the obvious target. Mill users and manufacturers hoped to improve the pre-mixing process in order to improve the milling process downstream. This is why, during the last couple of years, many mill manufacturers have adopted traditional rotor/stator mixers as their recommended pre-mixer.

These rotor/stator mixers have certainly improved pre-mix quality. But, ironically, improvements in pre-mixing have done a lot more than improve milling downstream. They have *reduced* the need for subsequent milling. In some cases, new-generation pre-mixers can actually replace media mills completely. The results include faster production, lower energy costs, and lower maintenance.

Batch rotor/stator mixers.

Like the HSD, a batch-style rotor/stator generator is submerged in a vessel, and it is mounted on either a hydraulic lift or a fixed tank. Horsepower demand for the rotor/stator mixer is higher – ranging from 10 to 20 HP per 100 gal – but the results are worth the price. Shear is much more intense, with particles subjected to a complex combination of mechanical, hydraulic and cavitational shear forces.

The traditional rotor/stator mixer is commonly used for such applications as pre-mixing fluid inks (flexo), color dispersions, automotive coatings, and coil coatings. They are also used to finish certain coatings that would otherwise require a quick pass through a media mill. This would include many carbon black and TiO_2 formulations.

The traditional rotor/stator mixer presents the classic compromise between shear and pumping ability. The rotor/stator mixer imparts intense shear, but it is a poor pumper. As viscosity rises, its pumping ability becomes even worse. The mixer generates excessive heat, which must be removed from the high shear zone. This is usually accomplished with an additional agitator, such as an anchor, which creates both axial and radial flow in the vessel. Thermal jacketing is often added to the vessel as well, to cool the batch.

With all the attention focused now on the pre-mixing stage, technological development in rotor/stator design is racing forward. New design concepts are addressing the heat problem with greater vortexing and more vigorous flow. Shear rates can be pushed to extremely high levels, because the heat generated is quickly removed with vigorous flow. This results in both faster mix cycles and smaller particle sizes. Some of these mixers are now finishing dispersions that previously required a media mill, and they show great promise.