How to choose the right mixer for high-viscosity mixing applications.

More choices for virtually all applications

A few years ago, the process of selecting a mixer for most applications was straight- forward. When increased demand required an increase in production, process engineers were naturally inclined to choose the type of mixer that had worked before in the same application. When they began talking to equipment manufacturers, their questions focused on capacity, auxiliary equipment, projected delivery and price. Many tested equipment before signing a purchase order. But they were mainly exercising "due diligence" – they were simply looking for proof that the mixer would work.

When a mixer was needed to produce a new product, the procedure was almost as clear-cut. Mixers generally fell into distinct categories according to such obvious operating parameters as the viscosity they could handle. Most manufacturers offer a "selection chart*" for their equipment in order to illustrate the boundaries of each mixer's operation. By tracing rows and columns on the chart, they could readily identify a mixer that would probably answer their needs.

Well, those days are over. The selection process is more complex today, because the capabilities of the most widely used mixers have expanded steadily during the last decade. If you haven't read an up-to-date mixer selection chart recently, take another look. You will find that the distinction between the mixers listed is now far less conspicuous than the *overlap* in their capabilities. This is especially true among heavy-duty mixers capable of mixing viscosities from 50,000 to 8 million cps (centipoise).

Greater risk – and greater return.

As mixer capabilities have expanded, markets have also expanded in all of the process industries. Many are already global. This expansion is great for enlarging sales opportunities, but it has also intensified competition. As a result, a mixer on the average process line today is no longer a generic production tool. Every mixer must be considered a decisive *business* tool, because profitability and competitive advantage often hinge on extremely subtle gains in mixing efficiency.

In practical terms, what does all of this mean? When the time comes to obtain a new mixer, you can no longer afford to buy without thoroughly surveying *all* varieties of mixers that can conceivably produce your product. Side-by-side tests often reveal surprising results that can lead to dramatic long-term savings or improvements in end-product quality.

The following tests in the Ross Test & Development Center trace the selection process at either end of the "high viscosity" scale. Each summarizes a mixing application and demonstrates the value of side-by-side tests to consider alternative mixing strategies.

Case 1: Plastisol

Application – Pigmented plastisols. Similar mixing applications might include: Dental whitening gels, polyester compounds, epoxies, transdermal drugs.

Ingredients – Plastisizers, pigments, fillers (Cabosil, calcium carbonate), powdered PVC resins.

Viscosity – Final: 50,000 centipoise (cps); max during the process: 2 million cps or 2.5 million cps, depending on mixer used.

Application Batch Size – 500 gallons.

Other Key Parameters – Pigments require high shear for fast and thorough dispersion. Vinyl resins are temperature sensitive – and therefore indirectly shear sensitive, too, since localized heat is always produced by a high shear agitator.

Process – The manufacturer in this case had been mixing a plastisol with a High Speed Disperser. The Disperser provided enough shear to disperse the pigment, but as viscosity went up it failed to maintain adequate circulation and product turnover in the vessel. Zones of unmixed material remained, even after very long batch cycles.

Test and Discussion

The following series of tests compares the process technique and results obtained using three mixer designs, a Dual-Shaft Mixer, a Planetary/Disperser, and a Double Planetary Mixer.

The three operate with different viscosity limits – from 350,000 cps for the Dual-Shaft Mixer up to 8 million cps for the Double Planetary, depending on the agitators used. But the biggest difference is seen in the basic approach to mixing in these types of mixers. In the Dual-Shaft Mixer and the Planetary/Disperser hybrid, we start with a substantial volume of liquid vehicle and build viscosity as we add solids. In the Double Planetary, the sequence is reversed. We generally begin with a small volume of liquid and artificially raise viscosity quickly. The elevated viscosity itself develops the shear required to reach a fine dispersion – without the need for a High Speed Disperser. This is especially advantageous when mixing abrasive materials, such as ceramic slurries and carbide composites, since agitator wear is worsened with high-speed devices. When the cycle is finished, we let down the batch with additional liquid to reach the target viscosity.

Design 1

Dual-Shaft Mixer - High Speed Disperser and Anchor Agitator. Capacity: 40 gallons.

Initial tests confirmed that an anchor agitator generated enough circulation to complete the batch successfully. The large, slow-speed anchor continuously sweeps the vessel wall and pushes material toward the interior of the vessel and the Disperser blade. This test was successful, with a reading of 5 on the Hegman Gauge. But experience in similar applications suggested that a switch to a higher-viscosity mixer might accelerate the process and improve end-product quality.

Design 2

PowerMix - High Speed Disperser and Planetary Blade, with vacuum. Capacity: 40 gallons.

The Ross PowerMix is a hybrid mixer that combines the high shear of a High Speed Disperser with the high-viscosity agitation of a planetary blade. Both agitators revolve on their own axes, while they both orbit the vessel – like the orbiting blades of a Double Planetary Mixer. Because both agitators are moving through the batch, the mixer does not rely on the natural flow of the mix material and it can handle viscosities up to approximately 2 million cps.

In this case, the solids were rapidly added to the solvent vehicle and dispersed. Vacuum at 29.5" helped to collapse the solids on the batch surface and accelerate dispersion. Direct horsepower readings indicated that the Disperser was drawing max power and operating at an optimal level. Viscosity reached a maximum of approximately 1 million cps, and the cycle lasted 20 minutes.

The batch was then let down until it reached the target viscosity of 50,000 cps. The result was a 6 on the Hegman Gauge.

Design 3

Double Planetary Mixer, with rectangular blades and vacuum. Capacity: 40 gallons.

In the Double Planetary Mixer we began by creating a viscous paste with all solids except the vinyl powder. Near 2.5 million cps, the mixer kneaded the heavy paste for 15 minutes and readily broke down agglomerates in the batch. The batch was then let down to approximately 50,000 cps and cooled before adding the temperature-sensitive PVC resins. Operating at 29.5" of vacuum, the powder dispersed easily. Once again, results measured a 6 on the Hegman Gauge.

Case 1 Conclusion- This manufacturer chose the Planetary/Disperser hybrid mixer, primarily to gain process flexibility. Compared with the Double Planetary Mixer, the PowerMix-style mixer allows high shear mixing at extremely low levels of viscosity (20,000 cps minimum, compared with 50,000 cps for the Double Planetary). Anticipating future needs on the process line, this mixer would also enable the manufacturer to complete the batch by cutting in an additional modifier that is heat-sensitive, using the Disperser after the batch has been let down.

Case 2: Silicone Sealant

Application – Viscous silicone gel used to manufacture an industrial sealant. Similar mixing applications might include: dental composites, butyl sealants, propellants, automotive sound absorbing compounds, color pigment compounding pastes, and chewing gum formulations.

Ingredients – Silicone resin and fumed silica.

Viscosity – Final: 6-7 million cps.

Application Batch Size – 200 gallons.

Process – Materials over 2.5 million cps generally require a switch from a conventional Double Planetary Mixer to a Double Arm Kneader. However, because of the high cost of a Kneader, it would be preferable to stick with the Double Planetary – if it is equipped to handle viscosities as high as 7-8 million cps, far beyond the normal range of classic rectangular planetary blades. In this case, the mixing process is challenging but uncomplicated. The resin is a liquid at room temperature. Fumed silica is the only additive.

Test and Discussion

The following evaluation describes the performance of a Double Planetary Mixer equipped with "HV Blades" in an application that typically requires a Double-Arm Kneader. By extending the working capacity of a Double Planetary Mixer from 2.5 to 8 million centipoise, these helical blades enable manufacturers in many applications to use a Double Planetary instead of the Kneader, at significantly lower cost.

Double Planetary Mixer with HV Blades and vacuum. Capacity: 40 gallons.

The vessel was charged with liquid silicone resin. With no need for added heat, the agitators ran at 18 rpm as fumed silica was added over a 15-minute period. Vacuum at 29.5" decreased the buoyancy of the fumed silica to accelerate wetting. With the fumed silica fully dispersed, the batch continued for another 15 minutes at 25 rpm. Inspection of the final product revealed that the silica was fully dispersed into the silicone, with the absence of agglomerations.

Case 1 Conclusion

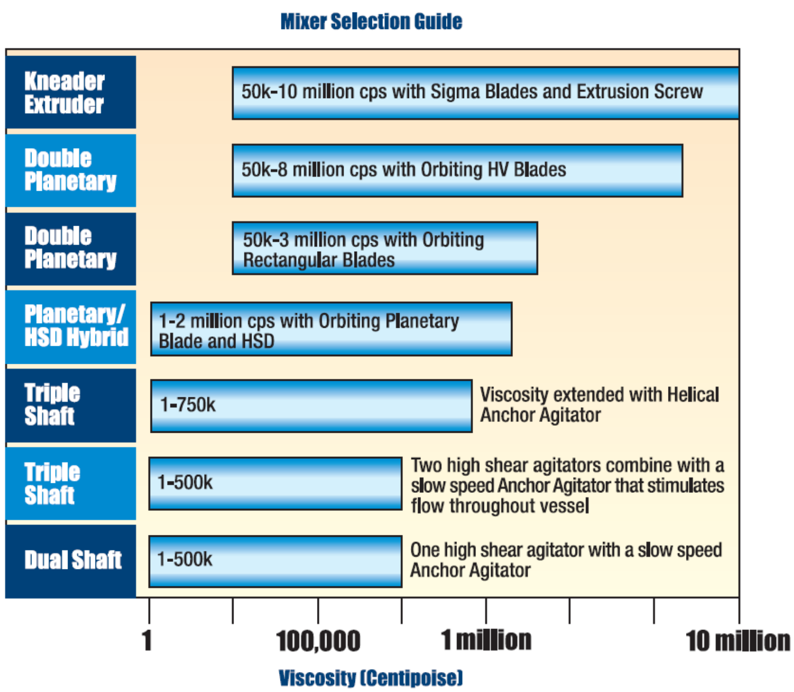
The Double Planetary Mixer has been operating on process lines around the world for at least 50 years. But the recent appearance of HV Blades has given the mixer a new role in many applications. As a substitute for a Kneader, it offers a substantial cost savings with no sacrifice in mixing efficiency. However, in cases where viscosity exceeds 8 million cps, or when extrusion is required at the point of mixing, a Kneader Extruder remains an indispensable alternative.

Sorting out the choices – in a laboratory with a spectrum of equipment to test.

As mixers in virtually every category – from simple Dual-Shaft Mixers to the newest Double Planetary Mixers and Kneader Extruders – become more versatile, mixer selection will become even more complex. But the rewards that result from careful, systematic comparison will be worth the effort. In the laboratory we often find that side-by-side tests can yield new insights in mixer selection, even for familiar applications.

Testing also gives us an opportunity to refine mixing *technique*. Working with the same materials that our customers use on their process lines, and replicating process conditions, the lab is an ideal setting to experiment with variations in charging, powder induction, shear rates, agitator combinations and speeds, the application of vacuum, and so on. With quantitative tools to measure the results, we can fine-tune operation and further improve mixer performance long before the unit is shipped.

To take advantage of these possibilities, arrange with your mixer manufacturer to test a variety of equipment under controlled conditions, using your own materials. Be sure to consider all the possibilities in mixer design. Be prepared to adapt your process "recipe" to match the equipment you test. Then, focus *quantitatively* on your test data. The test results and financial analysis that you take from the lab may well steer your process line in a new direction – toward greater profitability and competitive advantage!



Charles Ross & Son Company – 710 Old Willets Path – Hauppauge, NY 11788
Telephone: 1-631-234-0500 / Toll Free: 1-800-243-ROSS / Fax: 1-631-234-0691 / Email: info@mixers.com