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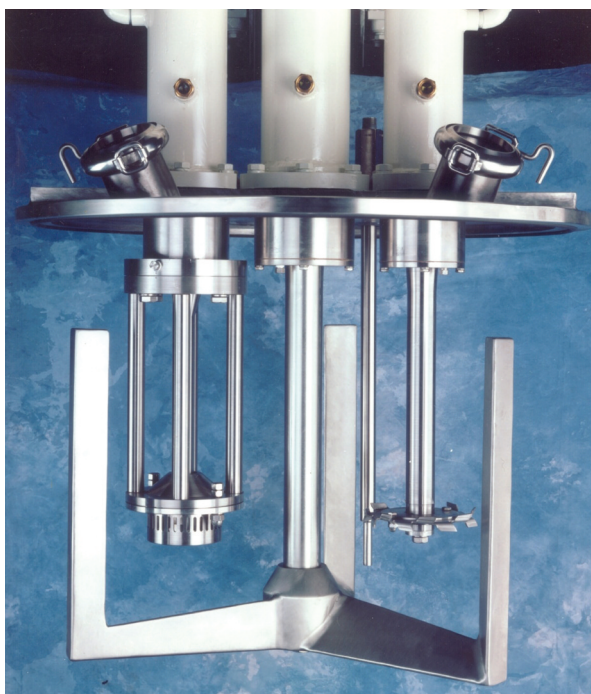
The art of high viscosity mixing

by Christine Angos-Banaszek, Charles Ross & Son Company

The process industry's move from low- to high-viscosity formulations is hardly a new trend and several mixer designs have more or less become the staple equipment for applications greater than 50,000 cps. Yet, many manufacturers still stand to gain a better perspective of how to best accomplish high-viscosity mixing. For purposes of discussion, let us define 50,000 cps and above as "high viscosity." Because viscosity itself is a measurement that can vary with other process parameters such as time, shear and heat, the viscosity numbers we pick here should be considered as loose estimations at best. The three broad categories of high viscosity mixers are as follows:

1. Multi-Agitator Mixing Equipment

This type of mixing systems is comprised of two or more independently-driven agitators working in tandem. A low-speed anchor compliments one or two stationary high shear devices (such as an open disc-style disperser blade or a rotor/stator assembly) which are particularly effective at fast powder wet-out, dispersion and particle or droplet size reduction. On its own, a disperser blade will produce acceptable flow patterns for products around 50,000 cps maximum; the rotor/stator is even lower, around 10,000 cps. Hence, there is a need for a supplement agitator to improve bulk flow, deliver viscous product to the high shear devices and constantly remove product from the vessel walls for better heat transfer. The common low speed agitator design is the three-wing anchor. For added efficiency, especially in terms of axial flow, the three-wing anchor can be modified to feature helical flights in between wings, or the vertical wings can entirely replaced with helical ribbons supported from the top and bottom. In combination, stationary high shear devices and an anchor will process materials typically as high as 500,000 cps.



A multi-agitator mixing system with independently-driven three-wing anchor, high shear rotor/stator and high speed disperser. This combination of agitators is typically suitable for viscous products up to 350,000cps.

Some Techniques:

- Begin the batch with enough starting volume so that the disperser blade and/or rotor/stator are well-submerged and thus can work properly without "slinging" materials to the walls.
- Load low-melting point ingredients first.
- Manipulate the speeds of the anchor and disperser in order to wet out powders as quickly as possible.
- If the starting viscosity is fairly low, you may benefit from a powder induction system that is available for some modified rotor/stator assemblies. Specially-designed rotors can generate vacuum strong enough to suck powders right into the high shear zone within the stator. Because difficult-to-wet-out powders are introduced sublevel, they do not get a chance to float on top of the batch or form agglomerates (fish eyes).
- As soon as powders appear to be wetted out, run the high speed disperser and rotor/stator mixer at the maximum speeds. As long as the power draws (amperage) are within the motor's range, running at the maximum speed is desirable as you benefit from the highest tip speed that the mixers can deliver. Well-designed mixers work just as optimally running at maximum speed as at lower speeds. Just look out for product splashing to the mixer cover and consider if your product is in any way heat- or shear-sensitive.
- Side and bottom scrapers on the anchor are highly recommended as these can dramatically shorten heating and cooling times.
- Mixing under vacuum has many benefits which include better dispersion, improved air-free product quality and elimination of costly and timely downstream deaeration steps.

2. Planetary Mixers

As product viscosity continues to build-up, a multi-agitator mixing system will eventually fail to produce adequate flow as can be characterized by an anchor simply carving a path through the batch (instead of pushing product away from the walls and into the center) or by high-temperature zones right near the disperser and rotor/stator assemblies. At this point, stationary agitators no longer suffice and a move to a planetary mixer may be recommended. The agitators of a planetary mixer rotate and travel through the mix vessel, passing through every point within the batch, not just along the periphery. Highly viscous materials must literally be carried from the vessel wall to the batch interior. While single planetary mixers are still commonly utilized for processing high viscosity applications, their successful use



Double Planetary Mixer with patented High Viscosity "HV" blades capable of mixing extremely viscous products as high as 8million cps. The mixer in this photo is a "reverse lift" design wherein the mix can is raised up and down, instead of the stirrers. The stationary ports can be hard-piped to accept mix ingredients.

is quite limited to products that are not too sticky, not too heavy, or those that will not ball up or tend to climb up the stirrer. For this reason, the double planetary is almost always the more practical choice. It can be equipped with traditional rectangular stirrer blades, finger blades or High Viscosity "HV" blades. The latter is a patented blade design of Charles Ross & Son Company which generates a down-thrust action due to its precisely angled helical contour. This sweeping curve firmly pushes the batch material forward and downward, a unique mixing action that solves the 'climbing' problem commonly experienced when processing highly filled materials. In addition, the HV blades do not have a lower crossbar so they can be lifted cleanly off a very viscous batch and pierce right through it as easily.

Some Tips:

- Ditch the scraper. It is commonly observed in most viscous mixing applications which are processed on planetary mixers that materials sticking to the walls tend to fold over by themselves and return to the batch. When scrap-



A hybrid planetary mixer featuring a rectangular stirrer blade and disperser shaft with two disc blades. The change-can feature allows for semi-continuous processing.

ers are used, they typically cause material to ride up into the gearbox area and help very little in the mixing aspect. Of course, there are exceptions to this recommended technique. In some occasions, product would not slough off on its own and scrapers are required in order to maintain an even temperature. Otherwise, not using scrapers is actually a plus.

- Start with all or a majority of the solids and gradually add liquids. Unless there are waxes or resins that need to be melted, it is recommended to artificially raise the viscosity by withholding liquids. The higher the product viscosity during mixing, the greater the shear that the planetary blades can impart into it. Viscosity may also be controlled by manipulating heat input to the batch. Operating at lower temperatures is therefore a two-pronged bonus: less energy requirement and improved shear input.
- Use a hybrid planetary mixer. Some highly filled and highly viscous formulations require a two-step approach to assure a properly dispersed batch. After mixing all ingredients in a double planetary mixer, the level of dispersion will still come up short of standard, hence a need to transfer the entire batch to a single shaft, high-speed disperser to provide the extra shear needed for completion. This cumbersome, two-step process is highly labor intensive and time consuming. To improve production efficiency, choose instead a hybrid planetary mixer that combines



Floor-mounted platen-style hydraulic discharge system. Viscous product is forced out through a valve in the side or bottom of the vessel, or through the top of the platen. A discharge system eliminates wasted hours of scraping heavy or sticky materials from a mix vessel.

the traditional thorough mixing action of a planetary mixer with the added benefit of a high speed disperser. Both the planetary blade and the high speed disperser rotate on their own axes while revolving around a central axis. The planetary blade orbits through the mix can in a circular manner, continuously sweeping the vessel walls, as well as the vessel bottom,

and carrying material toward the high-speed disperser. The close tolerance sweeping action of the planetary blade also insures that the heat which can be created by the disperser blade is evenly distributed throughout the mix. Variable speed allows precise control of shear rates to minimize the degradation of any shear-sensitive components.

- The challenge with processing viscous applications does not end with mixing. The discharge step sometimes becomes a process bottleneck when it doesn't have to be. Use of a platen-style hydraulic discharge system with a change-can design mixer improves speed, efficiency and cleanliness of the discharge operation. With the mix can positioned beneath the discharge system, a platen is lowered hydraulically into the vessel. A specially-fitted O-ring rides upon the vessel, thus the entire mix can wall is virtually wiped clean. Product is forced out through a valve in the side or bottom of the vessel, or through the top of the platen. A discharge system eliminates wasted hours of scraping heavy or sticky materials from a mix vessel.

3. Sigma-Blade Mixers

At the end of the spectrum of high viscosity mixing equipment are double arm sigma blade mixers and kneader extruders that can muscle through solid blocks of hard rubber. A sigma blade mixer is composed of two z-shaped blades that rotate toward each other at differential speeds. Each blade moves the material in opposite directions thereby providing excellent cross mixing of all raw materials. The blades pass the trough walls and each other at close clearances. This close clearance action provides a shearing and tearing action that is beneficial to the size reduction of solids such as rubber and plastic pellets. Once the mix cycle is complete the trough of the mixer can be tilted and the mixture is discharged to a secondary container for transfer to packaging or to downstream operations.

The kneader extruder combines the efficiency of a double arm - sigma blade mixer with the convenience of an extrusion screw for the mixing and discharging of heavy viscous materials. The counter-rotating kneading blades are mounted on a horizontal U-shaped trough, and in a separate cavity below the blades is a discharge screw. During the mixing cycle the blades rotate toward each other while the mixing screw rotates in a reverse direction, constantly feeding new materials into the mixing blades. After the mixing/kneading cycle is complete, the screw is reversed and it transports the mixed materials from the mix zone out through a discharge die and on to further processing or packaging.

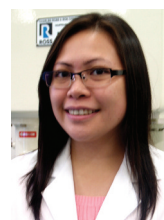
Something To Consider:

The kneader extruder remains to be the most powerful high viscosity mixing equipment and many companies have relied on this machine since the beginning. Yet, it is highly recommended to reevaluate your own application's mixing requirements. With the design advances in double planetary mixers, you may be surprised to know that your application can benefit from switching from the horizontal kneader to a vertical change-can mixer. Not all viscous applications are suitable for a double planetary mixer but for those that are, the benefits are far-reaching.

CONCLUSION:

In high viscosity mixing a number of equipment options exist. Many of their uses and functions overlap such that certain mixing applications can actually be successfully produced by two or more types of mixing systems. At this point, economics rules out the more costly alternatives. Arrange a visit to a mixer manufacturer's test center. Be sure to test a variety of equipment and techniques using your own raw materials, simulating conditions as close to your actual process as possible. Quantitative test results provide the best assurance that you have chosen the best high viscosity mixing system.

Christine is a regular blog contributor for Processing. Go to www.ProcessingMagazine.com and read her blog. You can ask Christine any question and have that question answered in her blog. For more information on Charles Ross and Son Company, go to www.mixers.com.



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