Re-introducing an American classic

The double planetary mixer, now for ultra-high viscosity materials.

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As international markets open and competition intensifies in all of the process industries, plant and process engineers must take special care to avoid making critical business decisions based on experience and presumptions that are no longer relevant. Especially if you are about to purchase new equipment for mixing, you should proceed cautiously. The evolution of equipment design is accelerating and the business implications of this transformation are huge. Even if your mission seems straightforward — to replace existing equipment, for example, or increase your capacity to continue producing a well-established product — if you haven't checked around recently for new equipment solutions, you could be headed toward an expensive mistake.

Distinguish between small production improvements and true paradigm shifts

In some cases, the latest evolutionary changes in mixer design are easy to spot. New design concepts for ultra-high-shear mixing, for example, are visibly different than their predecessors. In fact, many of the new rotor/stator generators designed for ultra-high shear mixing don't resemble traditional single-stage rotor/stator generators at all. The singe-stage rotor/stator mixer was introduced at least 60 years ago, and it is a familiar sight in many plants. The new generation of rotor/stator mixers present new processing choices that are easy for anyone to recognize.

Grasping the importance of design evolution in other mixer categories is not so easy. In high-viscosity mixing during the last few years we have seen a steady stream of improvements in such important components as drives, valves, seals, powder induction devices, discharge systems, vacuum drying, solvent recovery and fabrication techniques for handling pressure and vacuum. Many have contributed significantly to greater production and reduced process-line costs, and as you consider the selection of a high-viscosity mixer, you should factor them all into your cost/benefit equation.

One design "improvement" stands apart from the rest, because it has introduced both incremental improvements in many well-understood applications and a brand new role on the process line for one of the oldest mixers in use throughout the industrialized world — the double planetary mixer. By extending the double planetary mixer's working capacity from about 1 million centipoise to at least 8 million centipoise (cps), the helical "HV Blade" has given many manufacturers a new alternative to double-arm kneaders that is less expensive up front, less costly on an on-going basis, and far more flexible day in and day out.

Figure 1. Double planetary mixer with HV blades

Double planetary mixing — 50 years later

Despite a half-century of technical improvements, today's double planetary mixer operates in the same way that the first double planetary mixer did when Charles Ross & Son Company originally introduced it. Each of the two planetary blades in the mixer

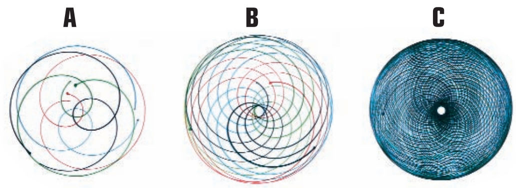

Figure 2. The double planetary mixer has typically been equipped with rectangular blades. Each turns on its own axis, while the two blades orbit the vessel on a common axis. In only 36 revolutions — just a second or two at customary speeds — the blades pass through every point within the vessel, physically contacting the entire batch.

revolves on its own individual axis. Meanwhile, because the two blades are mounted on a common, rotating drive assembly, they orbit the mix vessel on a common axis. As they advance, the blades constantly move material from the vessel wall and bottom into the batch interior.

The double planetary mixer is extraordinarily efficient at mixing heavy materials — from dense powders to highly filled slurries and composites. Powerful, variable-speed drives and heavy construction enable the mixer to operate over a wide speed range and deliver awesome torque, even at speeds as slow as 2-3 rpm.

Rectangular blades have always been the preferred choice for most applications (see figure 3). They are immensely strong, and the blades' vertical flights and horizontal lower crossbar are sloped to generate both radial and axial flow. When the mixer is fitted with Teflon scrapers, they are particularly effective at removing material from the vessel wall that would otherwise impede thorough mixing and efficient heat transfer.

In certain applications, when faster top-to-bottom mixing was required, "finger blades" have often been substituted for rectangular blades. While lacking the ability to scrape the entire sidewall continuously, finger blades stimulate vigorous axial flow with numerous horizontal flights. With each horizontal "finger" angled to direct flow downward, they also hasten the wetting out of powders added to the surface of the batch.

Equipped with rectangular blades, the double planetary is remarkably versatile as a mixer, vacuum dryer and granulator. It is capable of mixing materials like dental composites that are so viscous that you could easily stand on the surface of the batch. But near the top end of its working range it encounters other limitations besides simple viscosity. Extremely sticky materials such as silicone sealants tend to "climb" up the blades. This is especially true of sealants and other materials that are heavily loaded with fibrous fillers such as carbon or Kevlar™ fibers. The material balls at the top of the blades beneath the vacuum cover, which defeats the mixing process and requires cleaning that is often labor-intensive and costly.

The HV Blade concept — a helical alternative

This "climbing" phenomenon, as well as the need for faster wetting out, sparked the development effort that produced HV Blades. As the R&D process unfolded, Ross engineers began with a general goal of driving materials down into the batch, and soon recognized an opportunity to accomplish much more. The helical HV Blade concept overcomes many limitations of customary rectangular blades and enables the double planetary mixer to operate far beyond its traditional limits.

Each HV Blade consists of a pair of precisely-angled, helical flights that extend to the bottom of the vessel and trail gracefully as the blade revolves. There is no horizontal crossbar. As the blade turns, each flight drives material forward, down and inward.

Like the classic rectangular blade, the HV Blade passes very close to the vessel wall and constantly moves material from the wall to the batch interior. The key difference here is that the HV blade also generates excellent top-to-bottom mixing while it removes the layer formed on the wall and transfers it to the vessel interior.

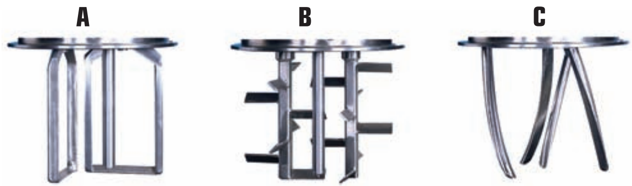

Figure 3. The three principal blade designs used today on the double planetary mixer: (a) traditional rectangular blades; (b) finger blades, an early design intended to stimulate greater axial flow; and (c) HV Blades, which stimulate better top-to-bottom mixing while they also allow higher-viscosity mixing.

The slope and spiral of the HV Blade are critical. While the blade forces material down into the mass of the batch, it also moves through the batch with far less resistance than a vertical rectangular blade. With resistance diminished, the blade is able to mix an extremely dense batch. Compared to the rectangular blade, the HV Blade can handle a comparable batch using less energy. Or, keeping input energy constant, it can handle materials at much higher levels of viscosity.

Several design factors, in addition to the downward thrust of the HV Blade, contribute to this advantage.

• Eliminating the crossbar reduces drag (and simplifies cleaning). Special fabrication techniques enable us to build the HV Blades so that they do not require the support of a lower crossbar, even when mixing extremely dense materials. The elimination of the lower crossbar significantly reduces drag. Incidentally, it also eliminates a costly maintenance problem with every batch. Sticky materials such as highly filled adhesives and sealants cling to the lower crossbar when the blades are raised from the vessel. This mass requires a lot of manual cleaning, which lengthens the mix cycle and increases costs.

• "Gradual" shear prevents amperage spikes. Whenever the vertical flights of a rectangular blade pass one another in a double planetary mixer, a significant shearing event occurs. When shear is imparted simultaneously along the entire length of the blade, this brief event draws substantial power. This moment of peak amperage draw (spike) — along with a peak load on the blades and the drive — presents another factor that limits the double planetary mixer's operating range. The power spike can also increase energy costs dramatically. Because HV Blades are swept back in a spiral, they pass one another with a continuous slicing motion. Overall, the degree of shear imparted to the batch is unchanged, but the amperage peak is flattened, and the operating range of the mixer is extended significantly.

• Edge contours. Because the leading edge of the HV Blade is broad and flat, it imparts a strong downward force. Meanwhile, the trailing edge is rounded, which helps to prevent "dead" zones in the wake of the passing blade.

HV paradigm shift — A new alternative to double-arm kneaders

With only a few exceptions near the lower end of the double planetary mixer's viscosity range, HV Blades make the mixer far more efficient. Whenever lightweight powders (like fumed silica or powdered pigments) are added to a liquid batch, HV Blades accelerate wetting out and dispersion significantly. But the most profound advantage that HV Blades offer becomes apparent with batches that exceed 1 million cps.

If you've worked with materials at 1 million cps or more, you know that this has traditionally been recognized as the upper end of the double planetary mixer's useful working range. Beyond 1 or perhaps 2 million cps, manufacturers generally have had to shift gears and mix in a double-arm kneader instead. From a business perspective, this is a crucial transition point because a double-arm kneader is significantly more expensive to purchase. New or used, it generally commands a price two to three times higher than a double planetary mixer with a comparable working capacity.

For more information, contact Charles Ross and Son Company at 800-243-ROSS or go to www.mixers.com.

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