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"More Efficient Pigment Dispersions"
Reprint Featuring:
The New Ross PreMax Rotor/Stator Mixer

Fluoropolymers

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Mildew and Algae Resistance



The *Race* is on

to Produce More Efficient Pigment Dispersions

During the last 30 years, pigment-dispersion technology has advanced in a relay race of development. As mill design evolved, many varieties quickly became popular, including ones that could handle heat and pressure more efficiently, and particle sizes dropped. Most of the gains in the milling process recently can be attributed to progress in media and raw materials. Now, the next round of process improvements are predicted to come from the premix stage that precedes milling.

By John Paterson / Product Manager for Coatings Applications, Charles Ross & Son Co., Hauppauge, N.Y.

Until recently, most coatings makers have considered premixing little more than a matter of wetting out powders and pigments prior to milling. For many years, a simple agitator in an open vessel was considered adequate to do the job. Propeller and turbine mixers were used in virtually every coatings plant across the country, and are still commonly used today.

High-speed dispersers, which offered a welcome improvement, came next. They seemed to break down agglomerates quickly, and made the overall wetting-out process much faster. With tip speeds of 5,000 feet per minute (fpm) or more, the high-speed disperser created more vigorous flow within the vessel, and it imparted more shear than a propeller or turbine. But the obvious advantages of the high-speed disperser also suggested its own replacement — high-speed rotor/stator mixers that could grind pigments finer.

Rotor/stator mixers have earned a reputation for fine-pigment grinding. Nevertheless, they did not make high-speed dispersers obsolete and take over the market for the following reasons.

The familiarity and comparative simplicity of the high-speed disperser continued to make it appealing, and for many coatings manufacturers, the gains offered

by the rotor/stator mixer didn't justify a switch to the new technology.

In many cases, the ordinary rotor/stator mixer generated intense shear but insufficient flow. The result was localized heat concentrated in the high-shear zone, and a need for a jacketed vessel.

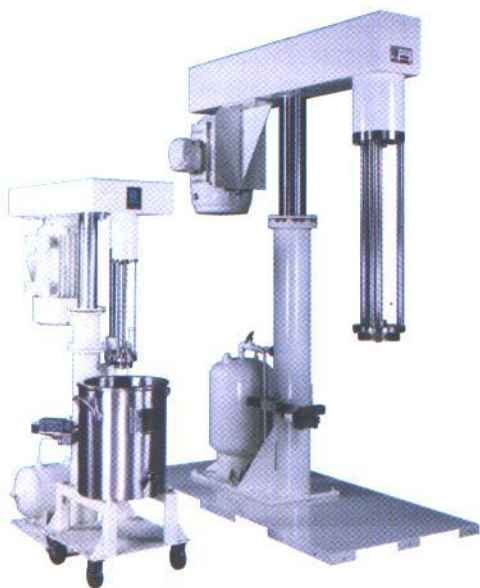
No one had yet realized that the wiser way to think of premixing and milling is as two halves of a single process, not two distinct processes.

Today, most fluid-pigment applications still involve a high-speed disperser dedicated to premixing, followed by a media mill (vertical or horizontal) that performs the actual grinding process. The product is either pumped through the mill one pass at a time or recirculated through the mill many times. In either case, the mill produces finished product at a slow rate — measured in gallons per hour, not gallons per minute.

Old attitudes have persisted, too. Even among those who switched to a rotor/stator mixer for premixing, few bothered to measure the particle size that resulted from premixing. Most of their attention was still focused on the milling that followed.

But all that has changed. Among many coatings makers, and especially among equipment manufacturers,

Figure 1 / The PreMax



The PreMax operates with new "Delta" rotor/stator technology that generates high shear, a double vortex and extremely vigorous flow.

Figure 2 / The Delta Rotor



The "Delta" rotor in the PreMax rotor/stator generator reflects the mixer's departure from conventional rotor/stator design. At high speed, the specially contoured rotor generates much greater flow than a traditional rotor.

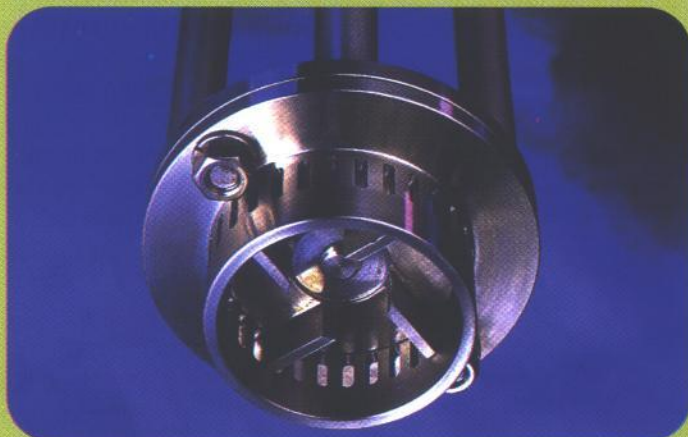
THE BASICS

of Rotor/Stator Mixer Design

All rotor/stator generators are comprised of a rotor that turns at high speed within a stationary stator. Material is drawn into the generator through the open end of the generator, then expelled through holes or slots in the stator. With close tolerances, mechanical shear occurs when each rotor blade passes a port in the stator. As the material exits the stator, the hydraulic shear that occurs is dependent upon the velocity of the material expelled. Greater velocity and more vigorous flow produce greater shear in the surrounding mix. Greater flow also helps to transport heat away from the high-shear zone.

Designed mainly to intensify mechanical shear with each pass through the mixer, multi-stage rotor/stator generators create more shearing events with each revolution.

Figure 3 / Single-Stage Rotor/Stator Mixer



But they do not generate increased flow, which turns out to be a serious disadvantage when premixing pigments such as phthalo blue and burnt umber. Heat generated in the high-shear zone requires vigorous flow to be dissipated safely. High-energy flow also enhances hydraulic and cavitation shear, which helps to accelerate wetting and deagglomeration.

Figure 4 / Multi-Stage Rotor/Stator Mixer



premixing is now seen as a vital part of the milling process. Mill design has leveled off, and continued gains in milling rely on their ability to improve processing upstream — in premixing.

Improved premixing can indeed have a profound impact on downstream milling. Following are some of the benefits.

- Better premixing can reduce the number of passes required through a mill to achieve the same end-results.
- It can reduce the number of mills required in a cascading process.
- In many applications, it can eliminate the need for subsequent milling entirely.
- An improved premixer can significantly lower capital costs and operating costs, and increase production.

A New Direction in Rotor/Stator Engineering

With the spotlight now on premixing, many have joined the race to develop more advanced rotor/stator mixers for pigment dispersion. But most have followed the traditional route in rotor/stator generator design and are stalled trying to overcome familiar problems. (See sidebar, "The Basics of Rotor/Stator Mixer Design.")

In rotor/stator generator design, the urge to concentrate on mechanical shear is hard to resist. After all, mechanical shear is the essence of a device comprised of a high-speed rotor turning within a fixed stator. Thus, the evolution of rotor/stator design has produced a great variety of rotor/stator styles and sizes. Engineers have explored the influence of rotor size, tip speed, tolerances between the rotor and stator, and the configuration of outlet ports in the stator. Lately, rotor/stator generators have emerged that include several rows of concentric rotors and stators, increasing the number of shearing events to which the mix material is subjected with each pass.

For some materials, this has improved the mixer's effectiveness as a disperser. Multi-stage rotor/stator generators break down agglomerates extremely aggressively. But for other materials, and many pigments in particular, this design approach has yielded disappointing results.

The problem is that as these rotor/stator mixers increase the mechanical shear applied to the pigments, they generate a great deal of heat but comparatively little flow. Especially as viscosity increases, the problem of concentrated heat in the high shear zone becomes critical.

Some manufacturers have added a slow-speed anchor agitator and scrapers to the jacketed mix vessel to promote flow and more efficient heat exchange. The anchor continuously scrapes the vessel wall, disrupting the

layer of cooled material that forms there, and impels it toward the center of the vessel. This is clearly an unsatisfactory solution. The added anchor makes the equipment unnecessarily complicated and costly to run. It also fails to overcome another common deficiency of traditional rotor/stator mixers in pigment-grinding applications — the mixer's inability to quickly draw solids down into the high-shear zone.

After manufacturing rotor/stator mixers for decades, Charles Ross and Son Co. decided to pursue a new approach to rotor/stator design. The PreMax (patent pending) is based on the realization that there is much more to shear than just mechanical shear, and a more balanced design strategy is likely to offer greater gains in efficiency. With a uniquely shaped "Delta" rotor, the PreMax rotor/stator generates intense mechanical shear and accelerates the mix material to a greater velocity than a typical rotor/stator mixer would.

The results for many fluid pigment dispersions are striking. The PreMax rotor/stator generator produces a more intense combination of mechanical, hydraulic and cavitation shear, which produces aggressive deagglomeration, vastly increased flow and much more efficient heat transfer.

Double-Vortex Accelerates Dispersion

All rotor/stator mixers generate a vortex beneath the open end of the rotor/stator generator. This draws material into the generator, where it is subjected to shear and expelled through the stator. The vortex generally occurs below the mixer head, but some manufacturers have tried inverting the rotor/stator generator in an effort to create a vortex above the generator and pull solids down from the surface into the high-shear zone.

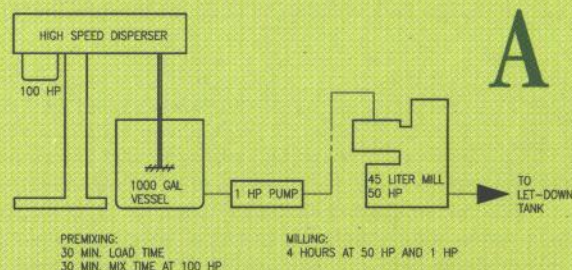
In the PreMax, the baffle plate that typically closes one end of the rotor/stator generator was removed to create a vortex both above and below the mixer head. With this double-vortex, solids are quickly drawn into the mix from the surface, and additional material is drawn from the lower portion of the vessel.

After subsequent tests, the baffle plate was reintroduced and made adjustable while the mixing process is under way. This allows the user to tune the vortex above the generator and thus the speed with which solids are drawn down into the batch.

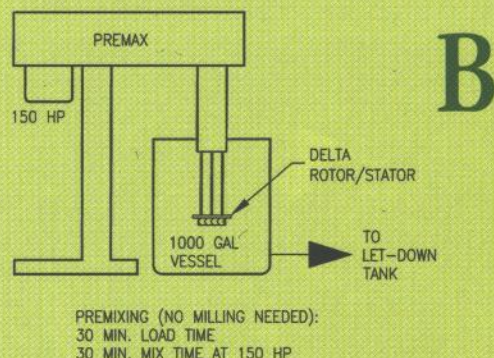
Process-Line Results

Quantitative laboratory tests and results in the field have demonstrated the value of the PreMax rotor/stator design concept. Pre-mixing with the PreMax generally produces results that are comparable to one or two passes through a media mill. Phthalo-blue, phthalo-green

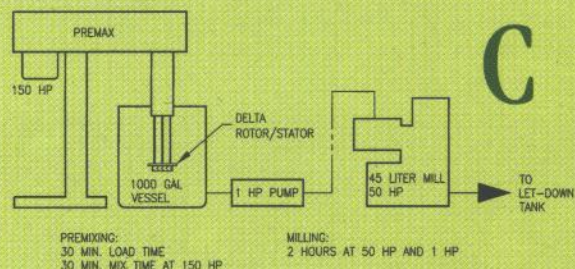
TYPICAL EQUIPMENT CONFIGURATIONS



Many TiO_2 dispersions require media milling after a cycle of pre-mixing. The usual configuration of equipment includes a high-speed disperser, a pump that moves material to the mill and controls recirculation, the mill itself and a letdown tank in which the viscosity of the mix is adjusted. Total time from pre-mixing through milling is five hours. Total energy consumption is 189.5 KWH.



By using the high-flow, high-shear Delta rotor/stator, the PreMax has eliminated the disperser, auxiliary pump and the 45-liter mill. Total batch time has been cut to 60 minutes, an 80% reduction. Total energy consumption is 55.9 KWH, a 70% reduction. (Note: This eliminates the waste and time devoted to clean-up required by the pump, piping and mill. The waste and clean-up time required by the disperser and PreMax are identical.)



For many phthalo-blue dispersions (including automotive grade, transparent and fluid-ink dispersions), the mill cannot be replaced with a high-flow premixer. But the milling cycle can be cut sharply, which produces an overall increase in production and a reduction in energy consumption. Final average particle size is <1 micron. Total batch time is three hours, a 40% reduction. Total energy consumption is 132 KWH, a 30% reduction.

Figure 5 / Pre-Mix Data Comparing PreMax and High-Speed Disperser for Phthalo Blue and Natural Burnt Umber

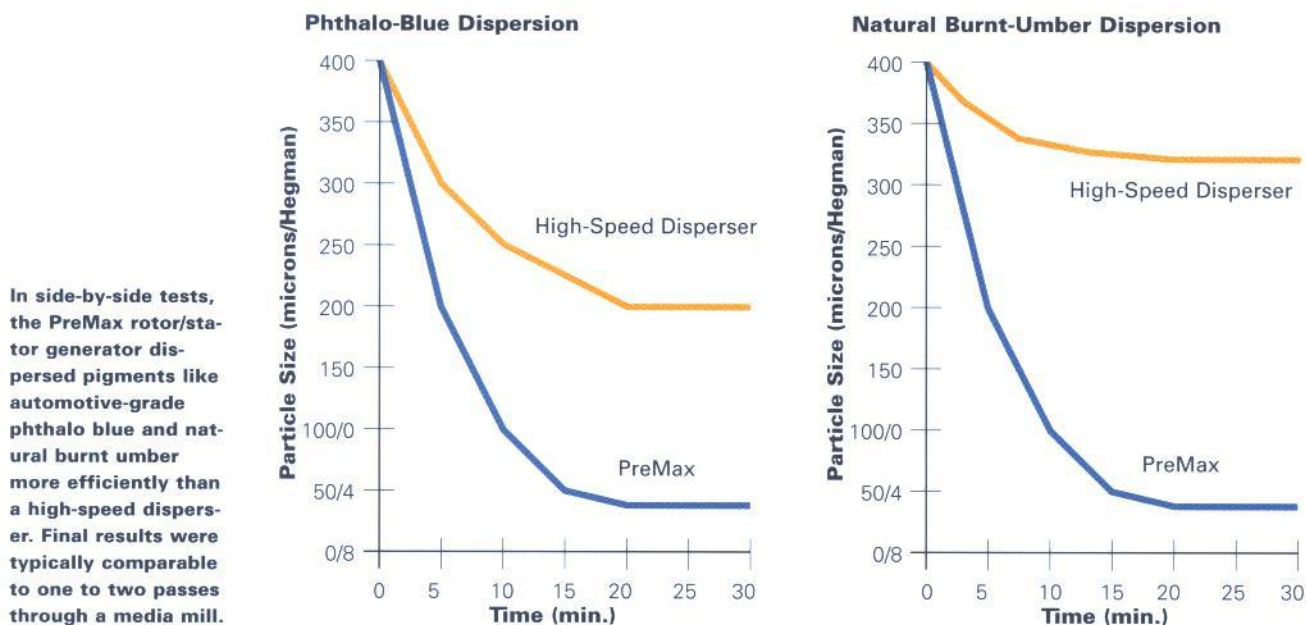


Figure 6 / Double Vortex and Flow Patterns



The PreMax rotor/stator generator draws material into the high-shear zone from both above and below. This promotes fast wetting and deagglomeration, as well as vigorous flow both radially and axially.

and burnt-umber dispersions typically produce average particles of 10 to 12 microns with the largest at 25 to 35 microns. Titanium dioxide (TiO_2) dispersions normally produce average particle sizes of 1 to 2 microns (largest = 10 microns). Batch times range from 15 to 30 minutes.

James Natalini, a well-known independent consultant in the coatings industry, said, "The Delta system is obviously an extremely aggressive machine." In a series of tests, he compared the capabilities of a Delta rotor/stator with those of a high-speed disperser and a conventional rotor/stator mixer.

Focusing on a phthalo-blue formulation, he reported, "The Delta system is very fast, achieving its results within one half-hour. Inclusion of all particles within the domain of a dispersion is impressive and exactly what a premix system should accomplish."

The high-flow Delta rotor/stator can reduce milling time by 33% to 100%. In other words, for many products that now require only one or two passes through the mill, the PreMax can replace the disperser and mill completely.

Natalini reports the same findings in his tests. "Other organic pigments should show a similar profile. With the proper formulation, TiO_2 and synthetic iron oxides may be completed on this device, and not require further milling."

For products that demand "off the gauge" (Hegman) or sub-micron dispersions, a media mill will still be necessary, but milling time can be sharply reduced — by as much as 50%. This produces corresponding reductions in energy consumption and equipment maintenance, while it increases throughput. ☼