

TECHNOLOGY BRIEF:

Inline ultra-high shear rotor/stator mixers are high-throughput low-maintenance devices capable of producing dispersions in the submicron and nano range. They offer a more efficient and cost-effective way of dispersing nanoparticles compared to conventional rotor/stator mixers, colloid mills and high pressure homogenizers.

New technologies for continuous mixing and homogenization of nano-filled materials



Shear-intensive mixing

Manufacturers often rely on inline rotor/stator mixers, colloid mills and high pressure homogenizers for continuous production of ultra-fine emulsions and dispersions. In recent years, the use of these shear-intensive mixing devices has extended to nano-enabled products, i.e. materials containing small amounts of nanoparticles. The nano-sized additives or fillers give rise to enhanced properties or provide new functionalities such as excellent wear resistance, increased tensile strength, lower density, higher conductivity, faster absorption, etc.

Rotor/stator mixers are the most economical and the easiest to operate as well as maintain. These consist of a rotor that turns at 3,000-4,000 ft/min within a stationary stator. As the blades rotate, materials are continuously drawn into one end of the mixing head and expelled at high velocity through the openings of the stator. The differential speed and close tolerance between the rotor and stator generate high levels of hydraulic shear, promoting fast mixing and breakdown of nanoparticle agglomerates.

When dealing with high-level dispersions that conventional rotor/stator mixers cannot successfully make, manufacturers switch to higher energy devices. Homogenizers use high pressure to force the product through a narrow-gap valve into a lower pressure environment. The pressure gradient across the valve and the resulting turbulence and cavitation all contribute to the disintegration of agglomerates present in a nanodispersion. The main drawbacks of these systems are cost, low throughput and tendency to clog. Oftentimes, intensive cleaning is required after each run.

Ross Ultra-High Shear Rotor/Stator Designs



X-Series

US Patent No. 5,632,596

The X-Series head consists of concentric rows of intermeshing teeth. Product enters at the center of the stator and moves outward through radial channels in the rotor/stator teeth. The combination of high tip speed and extremely close tolerances subjects the product to intense shear in every pass. The gap between adjacent surfaces of the rotor and stator is adjustable for fine-tuning shear levels and flow rates.



QuadSlot

The QuadSlot mixing head is a multi-stage rotor/stator with a fixed clearance. This generator produces higher pumping rates and requires higher horsepower compared to an X-Series rotor/stator set running at similar speeds.



MegaShear

US Patent No. 6,241,472

The MegaShear operates at the same tip speed as the X-Series and QuadSlot heads, but is even more aggressive in terms of shear and throughput levels. It consists of parallel semi-cylindrical grooves in the rotor and stator towards which product is forced by high velocity pumping vanes. Different streams are induced within the grooves and collide at high frequency before exiting the mix chamber.

Colloid mills, on the other hand, are essentially rotor/stator type mixing devices. A typical configuration consists of a conical or disk rotor and a stator; each piece has complementary grooves that serve as channels for the process fluid to flow through. Product is pumped between the rotor/stator surfaces and hydraulic shear forces are generated within this gap. Like homogenizers, colloid mills deliver low flowrates and are time-consuming to clean.

Ultra-high shear mixers

New developments in rotor/stator technology offer a number of viable alternatives to traditional mixing, milling and homogenizing equipment. At the forefront of these innovations are the Ross **X-Series, QuadSlot and MegaShear** Inline Ultra-High Shear Mixers. Operating up to 11,000 ft/min, these high-throughput, low-maintenance machines deliver better mixing compared to conventional rotor/stator mixers and colloid mills. The combination of high tip speeds and complex turbulent mixing patterns within the rotor/stator assembly quickly breaks down agglomerates and produces dispersions in the submicron and nano range.

When used as a pre-mixer prior to homogenization, an ultra-high shear mixer can reduce the number of homogenizer passes required to reach the final size distribution. This offers substantial benefits in terms of improved throughput and maximized utilization of the high pressure homogenizer. In some single pass requirements, the ultra-high shear mixer can replace the homogenizer entirely.

Simulation trials are recommended to confirm which rotor/stator design is best suited for a specific application.

Sample Application: Sunscreen Lotion

A sunscreen product containing nano-sized zinc oxide is batched in a Ross Multi-Shaft Mixer. The starting solvents and dispersant gel are first combined and heated under full vacuum. Once the proper temperature is reached, nano zinc oxide powder is added in increments.

When the formulation is complete, it is discharged and fed to the X-Series Ultra-High Shear Mixer. For the zinc oxide to be truly effective, average particle size must be no larger than 0.39 microns. A true single pass through the X-Series brings down the median particle size to 0.29 microns.

