

All about High Speed Dispersers

A White Paper Prepared By
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Abstract

The classic High Speed Disperser is a common mixing tool used throughout the process industries. This white paper discusses different designs, features, custom configurations and sample applications to serve as a helpful guide in equipment selection.

Introduction

The High Speed Disperser, also previously called High Speed Dissolver, is a standard workhorse used in the manufacture of chemicals, plastics, coatings, inks, paints, adhesives, composites and many other products. An economical and relatively simple piece of mixing equipment, its primary purpose is to incorporate powders into liquid and break down particle agglomerates to produce a fine dispersion.

Running at tip speeds up to around 5,000 ft/min, the open disc blade of the High Speed Disperser creates vigorous turbulent flow within a low viscosity batch. It also generates a characteristic vortex into which dry ingredients can be added for quick wet-out. The disperser blade may be located on- or off-center depending on the depth of the vortex (an off-center blade produces a smaller vortex and reduces air entrapment). As the batch thickens or increases in volume, blade speed is adjusted to maintain the vortex and rate of material turnover. A few other basic guidelines are typically followed in the sizing and operation of the High Speed Disperser, including:

- Normal operating viscosity range: water-like to around 50,000 centipoise (cP)
- Motor specification: 1HP for every 10 gallons of product
- Disperser blade diameter: approximately 1/3 of vessel diameter
- Disperser blade location: 0.5 blade diameter off the vessel bottom – 1.5 blade diameter below the batch surfaces.
- Full holding capacity of mix vessel: about 130% of batch size to provide sufficient freeboard above the product level.
- Typical blade designs:



Saw-tooth design.
Most popular blade; balances high shear dispersion with pumping action.



High vane design.
High pumping capacity and minimal shear; ideal for let-down requirements and heat-sensitive products.



Cutter design.
Provides good batch movement and high shear mixing; excels in high viscosity and high solids batches.



Polypeller.
Made from Ultra-High Molecular Weight Polyethylene for superior wear-resistance to abrasive applications.

Laboratory High Speed Dispersers

Most lab-scale High Speed Dispersers today, used for batches ranging from 1 to 15 liters, are conveniently equipped with an electronic lift for raising and lowering the blade. Heavier duty bench-top mixers feature an air/oil hydraulic lift, a set-up that resembles that of production-size floor-mounted models.

To accommodate variations in the batch size, different diameter disperser blades are supplied. The mixer base also allows users to utilize any number of commercially available glass beakers, metal cans or plastic buckets to serve as mix vessels. Vacuum-rated units, on the other hand, consist of a mixer cover that matches to a dedicated vessel. Sight/charge ports are installed on the cover for easy ingredient additions and for viewing the batch during the mixing cycle.

In an R&D setting, multi-purpose mixers designed for use with interchangeable agitators are very essential tools. Each agitator that easily swaps with another extends the spectrum of tests that a single machine can accomplish. Mixer versatility and utility are thus increased without taking up additional space. For this reason, Ross laboratory mixers are offered with different size disperser blades, propeller blades and rotor/stator assembly with different style stator heads.

While High Speed Dispersers are generally used for straightforward solid-liquid mixing requirements, rotor/stator mixers are utilized for emulsification, particle size reduction and homogenization purposes. Conventional rotor/stators, also called High Shear Mixers, consist of a four-blade rotor running at tip speeds in the range of 3,000-4,000 ft/min within a close tolerance fixed stator. This type of device imparts intense mechanical and hydraulic shear by continuously drawing product components into the rotor and expelling them radially through openings in the stator.



Laboratory High Speed Disperser with electronic push-button lift, shown here with a built-in thermoprobe.



Bench-top High Speed Disperser with air/oil hydraulic lift.



Vacuum-rated High Speed Disperser with custom vessels which clamp to the mixer cover for a vacuum-tight seal.



In a Ross laboratory mixer, the batch rotor/stator is designed to be easily swapped with a disperser assembly (and vice versa) without having to adjust or disassemble the pulleys, bearing housing, or shaft.

Pilot- and Production-Scale High Speed Dispersers

Dispersers equipped with a 5HP motor or larger are considered pilot- and production-scale mixers. The standard design is a floor-mounted unit with an air/oil hydraulic lift which allows the use of interchangeable vessels and the handling of low liquid volumes during the initial stages of mixing. Having the ability to raise and lower the disperser blade is also beneficial in terms of eliminating any “stratification” or possible layering within the batch. Vacuum-capable High Speed Dispersers may include a hydraulic lift but blade position cannot be adjusted during mixing. Instead, a secondary blade can be used to ensure proper batch turnover. Safety limit switches prevent operation of the mixer while in the raised position or without a mix vessel in place.

Tank-mounted dispersers are used in applications wherein the batch size does not vary or at least not severely. At all stages of the mix cycle, product level must always be sufficiently above the disperser blade’s fixed location. The mixer is installed on the vessel cover or an agitator bridge.



Standard floor-mounted model



Tank-mounted disperser



Vacuum-rated dual-blade disperser



Ross High Speed Dispenser
with Custom 50-gallon Tanks

APPLICATION SNAPSHOT

In a fiberglass pultrusion process, raw fibers are pulled and guided through a resin bath or resin impregnation system. The wetted fibers are then formed into the correct shape and excess resin is squeezed out before they are fed into a heated steel die to cure the resin. The finished product is a Fiber Reinforced Polymer (FRP) composite.

At one such manufacturing facility, a Ross 10-HP High Speed Dispenser supplied with eight (8) custom-made 50-gallon vessels is being used in batching the thermosetting resin. Pot life is limited so only small batches are made. Fillers, catalysts, pigments and other additives are charged through the loading hopper with safety grating and dispersed into polyester resin.

As one batch is underway, the next vessel is being filled with the proper amount of liquid resin. An air-operated diaphragm pump is mounted and plumbed to the bottom of each mix can for fast transfer of the finished mixture to the pultrusion line.



Mezzanine-mounted disperser with two-position swivel system

As batch volumes become larger, maintaining the recommended design parameters become more challenging. Because blade diameter is essentially determined by the vessel size, very large high speed dispersers eventually require horsepowers that are impractical.

Some attempt to solve this problem by installing a smaller diameter blade that runs at higher shaft speeds to maintain the desired ~5000 ft/min dispersion tip speed. However, this has the danger of approaching critical speed and increases the risk of premature equipment failure. A safer option is to utilize supplemental agitation, such as a slow speed propeller or an anchor agitator, to help “feed” product to the disperser blade, improve bulk flow within the vessel, and eliminate dead zones.

In cases where a multi-agitator set-up is not convenient, one possible solution is to work within a reasonable batch size and focus on ways to accelerate throughput.

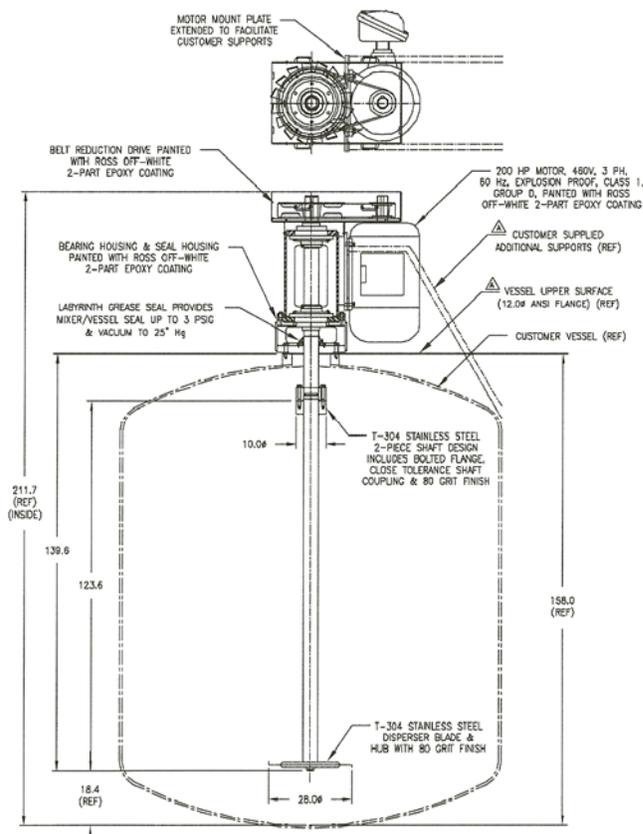
For instance, a High Speed Disperser equipped with a swivel system is capable of very fast changeovers. Typical tank-mounted dispersers cannot start the next batch until all contents of the previous run are emptied and fresh raw materials are charged to the same vessel. The mixing vessel is obviously operated and cleaned from a fixed location due to its large size. Thus any mixer that can be raised hydraulically out of one vessel, rotated and lowered into another vessel allows for a more nimble and cost-efficient production.

Very large High Speed Dispersers (75 to 500 HP) are typically built for mounting on a mezzanine. The photos on the left show a custom 100HP Ross High Speed Disperser with Swivel-Lock Assembly. The anti-rotation bar secures the mixer in a specific position during operation. After finishing a batch, the disperser assembly is raised out of the tank and rotated 90 degrees to service another vessel.



Ross 200HP High Speed Dispenser

- Tank-mounted
- 28" saw-tooth disperser blade, fixed position
- Maximum speed: 675 rpm
- Stainless steel 304 wetted parts
- 200 HP explosion-proof motor
- Variable Frequency Drive enclosed in an explosion-proof operator's station with on/off controls and speed potentiometer.



APPLICATION SNAPSHOT

A coatings and adhesives manufacturer is using a 200HP Ross High Speed Dispenser in the production of polyurethane-based specialty products which are applied to the surfaces of tracks, gym floors, courts and playgrounds.

The mixer is mounted on a custom flange designed to match the 19" diameter opening of an existing 6,500-gal tank. Adjustable packing and packing glands seal the vessel for up to 3-psig internal pressure (nitrogen purging purposes) and up to 25"Hg vacuum pressure (deaeration purposes). A Teflon lip seal is installed in the mixing shaft below the packing.

At this scale, lot-to-lot uniformity is very critical in optimizing yield and minimizing cost of production. Over many years of low-maintenance operation, the robust Ross High Speed Dispenser continues to deliver reliable performance and consistent mixing results.

High Speed Dispersers in Multi-Shaft Mixers

On its own, the disperser blade produces acceptable flow patterns for products up to around 50,000 cP. Beyond this point, if more solids are added or viscosity continues to climb, product turnover will start to slow down and eventually, batch material around the periphery can become stagnant. In addition to poor homogeneity, this situation increases the risk of product degradation due to overheating in areas around high speed blade.

When a batch process frequently suffers from insufficient product flow, consider upgrading your High Speed Disperser to a Multi-Shaft Mixer. For instance, in a Dual-Shaft Mixer, the disperser is complimented by a slow-speed anchor agitator which helps promote bulk flow and uniform batch temperature. The simple addition of an anchor extends the high speed disperser's viscosity range to several hundred thousand centipoise. A Triple-Shaft Mixer may also be used, wherein the anchor agitator works in combination with a disperser shaft and a rotor/stator assembly for increased shear input.

Sample applications of Multi-Shaft Mixers include pureed foods, sauces and syrups, hot-melt adhesives, rubber solutions, clay dispersions, cosmetic creams, medical gels, pharmaceutical suspensions, printing inks, specialty coatings, polymer dispersions, conductive pastes, lubricants, metallic and ceramic slurries, etc.



Different configurations of Ross Multi-Shaft Mixers.



Ross Dual-Shaft Mixer Model CDA-200

APPLICATION SNAPSHOT

A 200-gallon Ross Dual-Shaft Mixer is installed at a facility that produces nutritional supplements. The vacuum-rated mixer is used for making an intermediate product made of soybean oil, lecithin, food-grade wax and organic herbal powders.

The 20HP High Speed Disperser and 10 HP Two-Wing Anchor are each supplied with a Variable Frequency Drive. This provides the mixer exceptional versatility: the agitators can be engaged in any combination and at any speed for any interval during the mixing cycle. Although this sounds complex, Multi-Shaft Mixers are engineered to be operationally simple, effective and economical.

Mixers operating with independently-driven multiple agitators are particularly versatile, but they still have limitations in their range of viscosity. For example, as the product becomes too thick to flow freely, the anchor in a Multi-Shaft Mixer may start carving a path through the batch instead of turning it over. High-temperature zones near the disperser and rotor/stator assemblies may also start to form. When this occurs, the next logical alternative is a set of agitators that 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. This is the forte of planetary-style mixers.

High Speed Dispensers on Planetary Mixers

As viscosities reach 500,000 cP or higher, a planetary-style disperser will perform better than one with a fixed axis of rotation. One popular design is the Ross PowerMix which consists of a High Speed Dispenser accompanied by a stirrer blade rotating at a slower speed and both agitators revolve around the mix vessel. In one continuous mix cycle, the PowerMix can apply high shear and quickly disperse powders in a low-viscosity liquid. As the material thickens, the PowerMix can continue the mixing process even after the product has reached a high-viscosity, non-flowing state. The planetary stirrer blade continuously sweeps the sidewalls, as well as the vessel bottom, while carrying material toward the disperser blade. The stirrer also insures that heat created by the disperser is evenly distributed throughout the batch. For faster powder wet-out and dispersion, the high speed shaft can be fitted with two saw-tooth blades. Variable speed capability is important in controlling shear rates to prevent degradation of any sensitive components. Easily handling viscosity peaks as high as ~2 million cP, the PowerMix is ideal for processing highly-filled applications requiring ultra-fine dispersion quality.

Sample applications include viscous adhesives, sealants, molding compounds, plastisols, thick film inks, polymer bases, softgels, medical pastes and other specialty composites.

For even more demanding applications, manufacturers turn to the more powerful Planetary Dual Dispenser (PDDM). This mixer configuration consists of two planetary stirrers and two disperser shafts. The combined mixing intensity of all four agitators enables rapid incorporation of large amounts of solids into an already viscous starting liquid. Energy per unit volume is extremely maximized and stubborn agglomerates are quickly dispersed regardless of product flow characteristics.

The PDDM also offers a unique processing flexibility: the agitators are easily removable, allowing the mixer to be operated as a classic Double Planetary Mixer or as a PowerMix.



Ross PowerMix (US Patent No. 4,697,929)

APPLICATION SNAPSHOT

A supplier to the energy storage industry is using a Ross Planetary Dual Disperser (PDDM) in their production of electrode materials.

A typical process starts with the blending of dry ingredients – activated and conductive carbon powders – in the mixer. A portion of the binder solution is then added in increments, allowing the material to go through a very viscous stage so the High Speed Dispersers can deliver maximum shear and disintegrate agglomerates.

When the dispersion is complete, the remaining liquids are gradually added to bring the batch down to its final viscosity. The final stages of mixing are performed under vacuum to remove air voids in the finished product.



Ross Planetary Dual Disperser (PDDM) with two High Viscosity Stirrer Blades, two High Speed Dispersers and a scraper arm.