

Shifting high-speed powder induction into overdrive

Every process engineer who has worked with powders such as fumed silica, CMC, guar, xanthan, carageenan, alginates and other thickeners has come face to face with one of the toughest challenges in mixing. Many of the powders that are most often used in the process industries are hard to wet out and mix. They will float for hours on the surface of a liquid batch. Even with vigorous agitation, they'll sail in circles on the slopes of a vortex and resist being drawn down into the batch. Once submerged, they form agglomerates that continue to resist being separated and dispersed.

In-line mixing systems are designed to break down those agglomerates and wet out the solids. But many systems designed for powder induction actually create more problems than they solve. Especially in first-generation induction systems that combine a pump, eductor and rotor/stator mixer, clogging and maintenance problems can be unrelenting, while the mixing process slows to a crawl.

The cost of mixing hard-to-disperse powders — considering all of the process-line delays and maintenance costs that these powders cause in the process industries — is enormous. But today, many process engineers are looking at these powders from a new perspective. Precisely because powder induction is often the cause of bottlenecks, excessive maintenance costs and downtime, it also represents great opportunity.

The quest for a new way to mix and disperse lightweight powders began as an effort to solve one of the oldest challenges in mixing. But the result turns out to have much greater importance than that. By solving numerous production problems at once, the new SLIM (Solid/Liquid Injection Manifold) technology for high-speed powder

induction offers gains in overall production and profitability.

The system accelerates the mixing process without having to finance additional lines, equipment upgrades or construction; eliminates the costs associated with frequent clogging; and, in many cases, produces an improvement in end-product quality.

Five choices for powder induction: Which is right for your application?

1. An open tank and a propeller or turbine

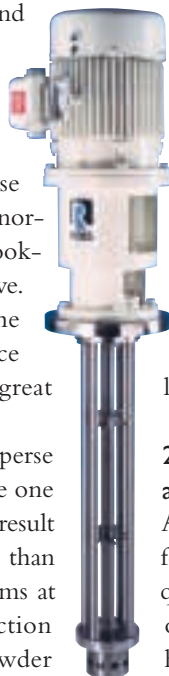
The simplest way to add powders to a liquid batch is to pour them into an open vessel. A propeller or turbine mildly agitates the batch and creates a vortex that draws material into the liquid.

This method remains popular because it is simple and inexpensive. For many manufacturers who are not facing strong competitive pressure or working with complex product formulations, it is adequate despite the very long mixing cycles required.

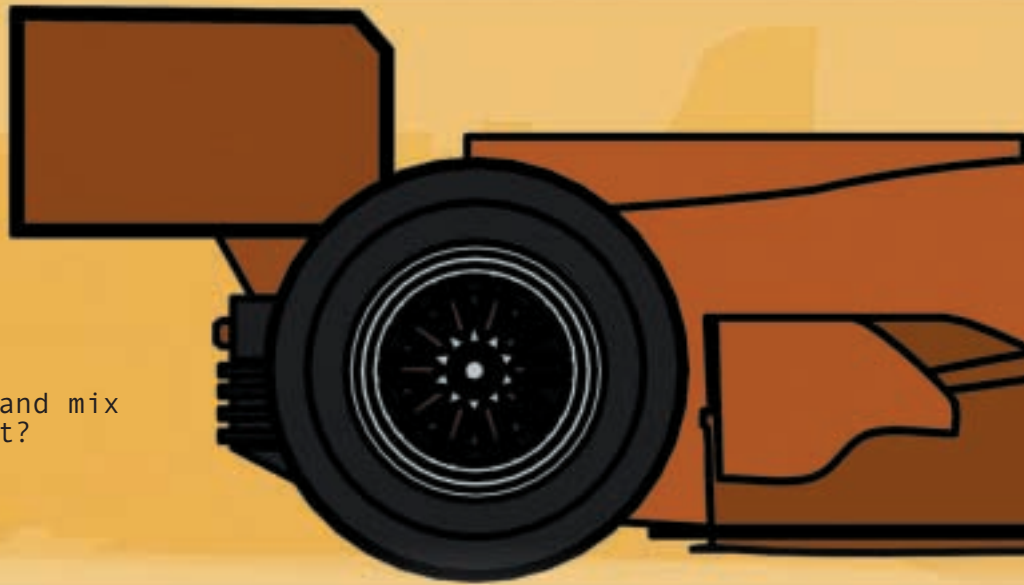
But adding lightweight powders into an open vessel can present other problems. Dusting, for example, brings particles into the air and creates an airborne hazard for employees. Open-vessel mixing also draws air down into the mix, and for many applications, this makes another step necessary later on, during which entrained air is removed.

2. A high-speed disperser speeds mixing and increases shear

A high-speed disperser (HSD) is a common choice for accelerating batch cycle and achieving a higher quality dispersion. Batch agitation is far more vigorous than with either a propeller or a turbine, and a higher level of shear is applied to the mix.



Can powders that are hard to wet out and mix become a thing of the past?



Like the prop and the turbine, the high-speed disperser suffers from the disadvantages of entraining a great deal of air into the batch and launching dust into the plant atmosphere.

In addition, a number of thickeners tend to foam when they are agitated violently in the presence of air. For many manufacturers, this means that the fast batch cycles promised by the high-speed disperser are impossible to achieve. The agitator must be kept throttled-down in order to keep the product in the tank.

3. A rotor/stator mixer accelerates deagglomeration and produces a finer dispersion

The classic single-stage rotor/stator mixer breaks down agglomerates much faster than the HSD. With close tolerances between the rotor and stator, it imparts more intense shear. The rotor/stator mixer is also more efficient than the HSD at drawing batch material directly to the high shear zone. As the rotor expels mixed material through openings in the stator, new material from the surrounding batch is immediately drawn into the high-shear generator.

The batch rotor/stator mixer produces a much finer dispersion than the high-speed disperser. But as with all batch mixing systems, its efficiency is limited by the flow pattern created within the vessel. Batch turnovers are calculated theoretically and controlled only indirectly. The wetting-out process is slow, especially when contending with lightweight powders such as fumed silica.

4. First-generation powder induction systems

Batch rotor/stator mixers were adapted for in-line operation several decades ago, and the first basic concept for powder induction emerged soon afterward.

In this system, a pump (A) accelerates liquid downstream into an eductor, creating a vacuum. Powder fed through an overhead tube is drawn by this vacuum into the eductor (B) where it joins the liquid flow. A rotor/stator mixer (C) then applies shear and mixing action, which breaks down agglomerates, positively mixes the powder and liquid, and propels the flow downstream (See Figure 1).

In its day, the system offered a useful tool for powder induction. The in-line system eliminated the dusting and floating of batch systems, and it offered much more precise control over the mixing process.

But the new system also presented some serious limitations. With three separate devices in series, maintenance — in terms of labor, required expertise and spare parts — is intensive. Balancing the performance of the pump, eductor and mixer is often difficult, and in many applications, downtime is quite high.

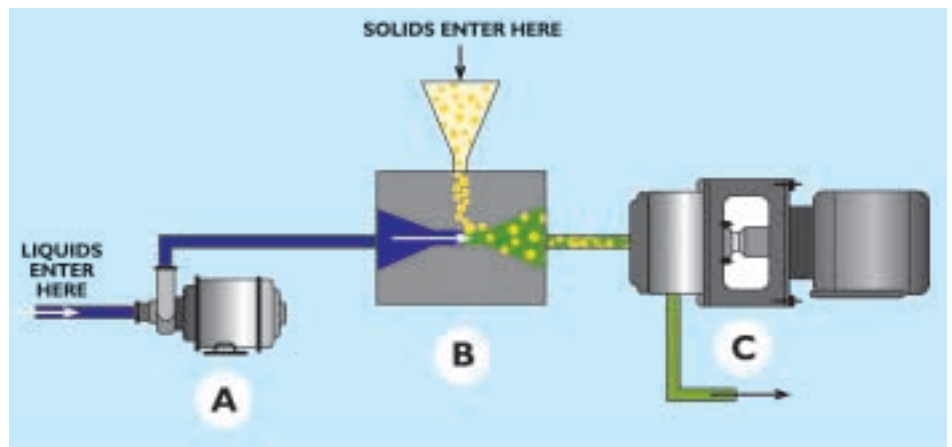


Figure 1



The rotor/stator generator in the SLIM system draws a large volume of powder (shown in yellow) into the high shear zone, where it is simultaneously combined and mixed with the liquid stream (blue).

The most serious limitation of this system relates to the inherent operating limitations of the eductor. Clogging is routine. The system is temperamental and requires a lot of operator experience and attention to operate successfully.

Since the feed rate of the eductor relies on the vacuum created by a fast-moving stream, it is also extremely viscosity-dependent. As the viscosity of the stream rises, velocity falls and the efficiency of the eductor drops off steadily until it finally stops.

5. Powder induction shifts into overdrive

The design breakthrough that gave us the current generation of powder induction systems was based on one simple idea — eliminate the eductor.

In the older designs, the solids were combined with the moving liquid stream in the eductor, then mixed farther down the line. That stretch between the eductor and the mixer was critical, because the material that had been combined but not yet mixed was prone to clogging before it could reach the mixer where agglomerates would be disintegrated and small particles forced into a dispersion that could flow quickly without problems.

In the SLIM system, solids are combined with the liquid flow at precisely the point where positive mixing takes place. A specially modified rotor/stator generator equipped with Progressive Spiral Porting creates a powerful vacuum and draw the powder directly into the high shear zone, where it is instantly dispersed into the liquid stream.

Simultaneous combination and mixing provides greater process flexibility

High-speed transport of initial dispersion

When solids and liquids are combined and mixed simultaneously, agglomerates are prevented from forming because dispersion is virtually instantaneous. As always, subsequent passes through a downstream rotor/stator generator can improve the dispersion, but

the initial dispersion is immediately transportable at high speed with little risk of clogging.

High-viscosity threshold, high-solids loading rate

Another great advantage of simultaneous combination and mixing is that the SLIM system can handle liquids at much higher viscosities than the eductor-based system can handle. Although the stream velocity falls as more solids are inducted, the mixer forces the flow to continue moving downstream.

For pseudoplastic materials, the viscosity limit is even higher

When working with materials that exhibit pseudoplastic (shear-thinning) properties, the system can handle extremely high viscosities. This is precisely because the viscosity of a pseudoplastic material falls when it is subjected to shear — the moment when powder is inducted into the fast-moving stream. With the viscosity artificially lowered in the mix chamber, the fluid can tolerate extremely high-solids loading, and the system's capacity easily reaches a viscosity of 100,000 centipoise.

Powder injection prevents dusting, lowers risk of explosion

By preventing dust from escaping into the plant atmosphere, the system eliminates a significant respiratory hazard and lowers the risk of explosion in the plant. Dust has virtually no opportunity to escape into the air, because the powder is mixed directly into the liquid stream in a closed system.

Measuring the value of faster powder induction in the lab

Every production manager operates with their own unique equation for balancing cost and production. But this much is certain: When your mix cycle is stalled waiting for powders to wet out, your profitability is losing altitude. And when your line shuts down because an eductor needs to be unclogged, your profitability crashes.

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