PSI-Mix™: A True 21st Century Industrial Mixer

Novel Powder Dispersion Method Dramatically Reduces Processing Time for Industrial Mixing System

The problem of mixing fine powders in liquids is something most everyone experiences regularly. Even if you're simply trying to mix cocoa powder in milk or powdered soup in boiling hot water, the problems become clear very quickly - cold or hot, powders don't disperse quickly in liquids, even when speeding the process with agitation. Impatiently dunk the powder under the surface with a spoon and the result is a mess of lumps (agglomerates) that don't go away, regardless of the amount of shearing force that is applied.

Accelerating the industrial process of adding a large quantity of powder into liquids to make a homogenous product isn't really that much different. It's just that the action takes place on a significantly larger scale. Owing to the limited wetting surface and high shear in traditional batch type industrial mixers, it takes a lot of patience and energy over a long time to overcome the inevitable agglomerate problem.

This article takes a look at the fundamental problems associated with fine particle emulsion and dispersion in liquids. It also touches on the inherent nature of fine powder particles to form unwanted agglomerates, as well as on the physical interplay between liquid surface tensions and air pressure encased within agglomerates. It further examines the forces at play that slow down the mixing when large quantities of fine particles (<10µm) are dumped into industrial-size mixing tanks filled with liquids.

Re-Engineering fine powder/liquid mixing

The lack of significant improvement in industrial mixing processes over the past 50 years isn't for want of trying; a quick search online reveals over 400 industrial mixer suppliers. Despite a seemingly wide array of choice, however, there is little variety across the underlying technology.

The industrial fine powder/liquid mixers in use today are essentially giant, upsized versions of a soda fountain "milk shake mixer" – a motor-driven propeller in a cup. These high-shear "propeller-in-a-tank" mixers are found in every plant that mixes powders with liquids to produce homogenous paints, coatings, inks, foods, and many other items. Besides being inefficient at mixing, and very time consuming, each step in the process is ponderously sequential.

But a major change is coming. NETZSCH Fine Particle Technology has developed a completely new industrial mixing technology, the PSI-Mix (Ψ-Mix©), that addresses the forces at play during the mixing process at the micron level.

The new technology also brings with it a new look: Gone is the familiar high-shear agitation "propeller" in its hundreds of forms. Gone are the painfully slow mixing operation, the wasted floor space and the high machinery costs. This new mixing technology speeds the production of paint, inks, foods, drugs, and hundreds of other applications to one-tenth the usual time, using one-tenth the production floor space and one-tenth the power – improvements that can result in capital equipment savings in the range of hundreds of thousands of dollars.

To see how it achieves these major improvements, it is useful to examine the main problems that plague traditional mixing systems.

Fine powder wetting challenges

Ideal dispersion is achieved when fine powders come into contact with a large liquid surface under low shear. Figure 1 portrays the general principle. Attempts at improving industrial mixers have been self-defeating because they fail to satisfy these ideal conditions.

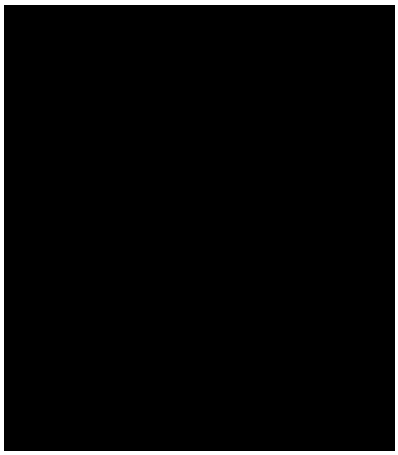


Figure 1. Basic Dispersion Principle

Manufacturers that mix large, 500-plus-gallon batches of paint, inks, coatings, and foods are all too familiar with the persistent problems that prevent fast homogenous dispersions. To avoid exceeding the absorption rate of the very limited liquid wetting surface, the dosage rate of the powders fed into it must be greatly slowed. It should be recognized that the surface forces in dry solid powders less than 10 microns form extremely cohesive agglomerates which resist the required capillary action.

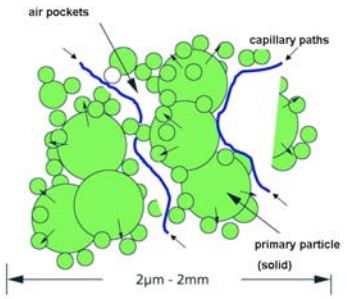
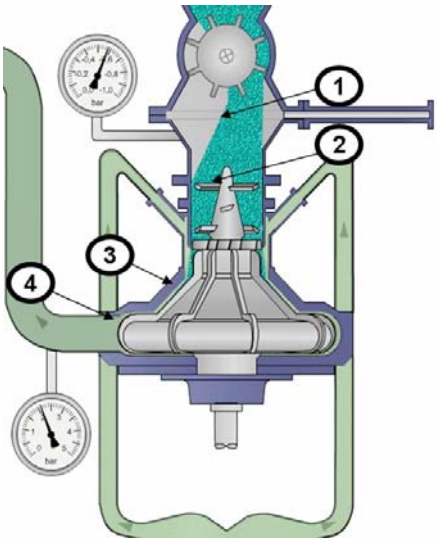


Figure 2. Dry Agglomerates

Ideally, these agglomerates are broken up before being presented to the liquid. Not doing so requires the generation of high shear forces over a long period of time to achieve results that even approach acceptable, and results in high temperature gains, wasted powder consumption, and slow, costly production.

PSI-Mix takes the opposite approach. Instead of slowing powder loading, it pre-disperses the dry powder particles prior to wetting in the vacuum chamber. Additionally, it creates a significant wetting surface, 2m² /sec, which is key to the technology's success. Particles come in contact with the wetted surface instantly instead of being allowed to cake up in lumps.



One	Capillary air is removed from the agglomerate by means of vacuum
Two	Dry agglomerates are dispersed and released in vacuum
Three	Dry dispersed particles are dipped into the liquid and wetted
Four	Liquid is hydraulically pressed into the capillary paths (system pressure)

Figure 3: Basic PSI-Mix *Process*

By pre-dispersing the powder particles in the dry state and increasing the availability of a liquid surface area through a vacuum eductor system, the rapid loading of powders can be sustained in an enclosed, environmentally safe process. PSI-Mix's production capacity is typically seven tons. or 10-cubic meters, of dry solids per hour.

Wetted agglomerates are very difficult to disperse because of the pressure of trapped air between particles which prevents further hydraulic penetration (See figure 4). Within the PSI-Mix chamber, a controlled negative-to-positive pressure gradient forces any trapped air from small agglomerates to break them up into a homogenous mixture.

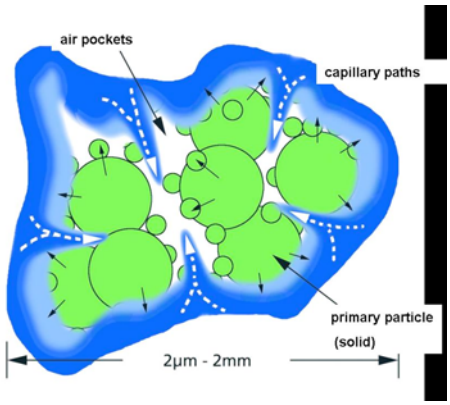


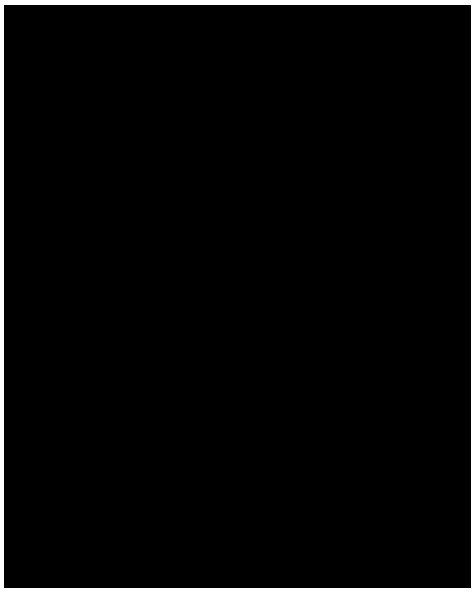
Figure 4 Wetted Agglomerates

Revolutionary New Mixing Technology
Recognizing these challenges, NETZSCH Feinmahltechnik GMBH developed a revolutionary inline disperser technology called the PSI-Mix. PSI-Mix is a safe, clean, dust-free, and totally enclosed process. It can handle batch sizes of 55 to 5000 gallons, or work in a continuous process to produce homogenous products with a mix viscosity as high as toothpaste. It can also be installed easily into existing systems to utilize existing tanks and speed up current processes - reducing temperature rises and enclosing the process to reduce hazardous emissions.

PSI-Mix is not the typical industrial mixer. PSI -Mix is a self-contained, four-stage batch or inline process. Its innovative pre-wetting dry powder dispersion, virtually infinite wetting surface, and elegantly simple vacuum-to-pressure gradient reduces mixing time by 90 percent compared to traditional mixing methods. As a result, manufacturing requires far fewer machines, far less plant space, and far less energy consumption. The result is a more cost-efficient manufacturing process.

PSI-Mix literally redefines how industrial mixers look and operate. In a typical industrial application, one PSI-Mix does the work of 10 normal mixers, in one-tenth the space.

PSI-Mix in-line process: ***How It Works and Why It's So Much Faster***
The PSI-Mix inline disperser is a fully automated process, designed for continuous dosing of raw materials into liquids or for batch operation with a holding tank. The PSI-Mix operating process can be divided into two stages: (1) starting/dosing and (2) dispersing and emptying. Each of these stages is explained in detail.



1. Solids feeding via rotary valve
2. Connected solid disintegrator
3. Tangential entry of the suspension into the acceleration chamber
4. Wetting of the solid in cyclone with high surface
5. Cone-shaped compression zone with cooled housing
6. Solid feeding tunnel with safety slide valve
7. Wetting stream pump with high feeding capacity
8. Circulation tank with agitator
9. Rotor as liquid ring pump
10. Outlet of the suspension at the largest diameter.

Figure 5. The PSI-Mix

Starting/Dosing Stage: Prepared liquid fills the batch storage tank. Fine powder solids are pre-weighed and positioned in the feed hopper above the controlled powder-feed rotary valve. Alternatively, solids are fed into the tank from a silo, containers, or bags. On startup, liquid is fed at high speed from the storage tank through four nozzles to the PSI-Mix contact zone where it creates a virtually infinite wetting wall for powder absorption. A suction vacuum, or Venturi effect, is formed above the rotor.

The feeding of fine powders, pre-dispersed by a rotor before wetting, can begin once a vacuum is established. By removing air pockets in the solids, PSI-Mix shifts a three-phase (solid-air-liquid) system into a two-phase (solid-liquid) system. The solid particles are wetted in a cyclone and dispersed in an acceleration zone within a closed housing. System pressure controls the dosing rate. Overdosing is prevented automatically based on ambient pressure measured by the unit.

The tremendous suction results in rapid powder incorporation and is the key to the dramatically faster mixing speed associated with the PSI-Mix. The liquid mix then flows directly back to the batch tank under pressure. An innovative vacuum-to-pressure gradient through the wetting zone results in additional wetting acceleration. The output pressure ranges from 1.5 to 3 bar, depending on the pressure drop in the return line. The entire process is completed with product temperature varying no more than 5ºC through the mixing process.

Dispersing and Emptying Stage: This stage begins when the solid feeding is complete. Depending on the characteristics of the product requirements, the suspension can be homogenized or de-aerated for a specific period of time. A wide range of product viscosities can be accommodated, up to the consistency of toothpaste. A large liquid surface is formed by the high throughput, and the mixing and further dispersion of the particles occurs in a long compression zone. Finally, after the batch tank has been emptied, the product is quickly flushed out of the small mixing zone, which is then ready for another batch from the same or another holding tank. One PSI-Mix inline mixer can be configured with multiple holding tanks to multiply productivity up to 10 times.

Figure 6. PSI-Mix© Machine.

The PSI-Mix also offers dust- and emission-free dispersion within a completely enclosed process chamber, making it an ideal alternative to vacuum feeding.

Applications

The PSI-Mix mixing system can be used in a variety of applications, including food products, architectural paints, automotive paints, filler pastes, industrial paints, liquid printing inks, paste inks, screen printing inks, pigment dispersions, powder dispersions, resin dispersions, and specialty chemicals. It is especially well suited for products with high solid content, products with low solid content in large liquid batches, and products with difficult wetting solids.

Batch or Continuous Plant Process Flexibility

The liquid and powder input and output is actually independent from the PSI-Mix. In a batch process layout, PSI-Mix will handle multiple feed hoppers and multiple holding tanks for almost continuous batch operation. During in-line process mode, inputs and outputs are fed continuously to and from holding areas.

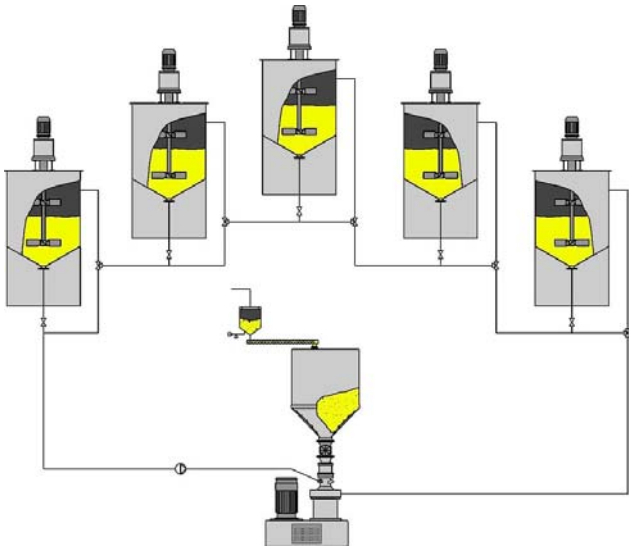


Figure 7. Multiple Holding Tank Batch Process

Conclusion

The PSI-Mix has been available only for a short time, but its potential to improve mixing operations is already clear. The fundamental concept of pre-conditioning powders in a dry state prior to feeding is well known; however, the concept of performing this procedure in a totally enclosed area immediately preceding wetting is revolutionary. The subsequent problem of how to feed a large, dry surface area into a liquid is addressed by increasing the amount of liquid surface area available through an increase in the flow rate. The novel methods used to resolve this problem create a high velocity liquid tube, using a multi-port liquid injection, that results in a vacuum effect to de-aerate the system and draw the powder immediately into the liquid. This method also prevents splashing and powder buildup, thus facilitating cleanup.

The PSI-Mix reduces long-term capital costs associated with production expansion, because an additional holding tank is all that is required, rather than a more expensive tank combined with cooling and a high-shear disperser. It also reduces overall operating costs through the use of an automated control system (included with the machine) which ensures repeatable product quality.