A New, Shear-free Dispersion Process for automate Production

Peter Schertenleib, NETZSCH-Feinmahltechnik GmbH, Selb, Germany
info@nft.netzsch.com, www.netzsch-grinding.com,
phone +49 9287 797-0, fax +49 9287 797 149

For as long as man has attempted to mix solids with liquids, he has struggled to avoid an annoying, if not wholly unacceptable, byproduct – lumps, or more scientifically, agglomerates. In the case of a single serving of a food product, as in your morning coffee when you add powdered creamer, these agglomerates may be merely objectionable. In the case of a large batch of high-value product, such as pharmaceuticals or fumed silica slurries, agglomerates can render the product useless, or greatly increase production time by creating the need for a grinding or pulverization process.

Introduction

Starting with the fundamental idea of wetting finely dispersed powder in a large liquid surface, the revolutionary inline disperser Ψ-MIX® was developed by NETZSCH-Feinmahltechnik GmbH. Effective wetting of solid particles by high-quality dispersion improves quality and enables unmatched operation of the machine at high production rates.

The Ψ-MIX® combines a new dispersion method with an emission-free inline process. The solid components are dispersed on a large liquid surface created by a high suspension flow through the narrow process zone. Since the new machine is capable of processing both low- and high-viscosity suspensions, the entire application range of dispersion technology is covered. Applications for temperature-sensitive or shear-thickening materials are easily processed within the design of the process chamber.

Compared to conventional rotor-stator systems, this machine uses significantly less energy for dispersion. Temperature-sensitive products and materials with a broad viscosity range can be processed. The Ψ-MIX® can be easily integrated into automated plants that process large batches and is especially suited for emission-free and explosion-proof operations (*Figure 1a*). The design of the machine is distinguished by the fact that foreign bodies in the pigment suspension do not cause damage to the system. A further significant feature of the Ψ-MIX® that contributes to its success is the deaeration function that occurs automatically within the operating method of this new machine. This is a major improvement for processing water-borne suspensions.

For batch sizes starting from 15 l up to 700 litres of suspension, the pilot plant and small batch version *MICRO* Ψ-MIX® (*Figure 1b*) was recently developed. With this machine being designed for tests and the production of small batches, a safe scale-up to the production machine guarantees a high degree of safety and flexibility. On the production sized machine batch sizes between 100 and 15,000 litres can be processed.

Table 1: Technical Data

	***MICRO* Ψ-MIX®**	**Ψ-MIX®**
Drive power [kW]	5	22 – 75
Speed range [min^{-1}]	1000 – 3000	500 – 2000
Solid throughput [m^3/h]	0.3	> 5.0
Suspension flow [m^3/h]	1 – 2	15 – 25
Feeding pressure [bar]	> 2.0	> 3.5
Batch quantity [l]*	15 – 700	100 – 15,000

* as a guideline

Comparison of different methods for dispersion

For highly viscous products there are low speed systems like Butterfly Mixers and High Speed Mixers with finely toothed discs based on cavitations (cavitations disk). All these systems are used to wet out dry particles with liquid components, but no defined measurement can tell about their efficiency factor. A very special method which is described as sub level feeding is showing already energy savings.
The wetting process as such cruises as a black box with the pseudonym dispersing process which defines only the result of quality. May be the future will find a new definition like coating- or wetting-process of micro powders.

When comparing the variety of different dispersing systems the relevant literature is not supporting production parameters. Equations mainly support mechanic layout of mixing systems to determine power requirements. The field of efficiency linked to the applications and information about specific energy remain undefined. *Figure 2* shows the most common system groups with saw disks and butterfly tools in comparison to the Ψ-MIX®, specified by installed power, which seems to be an indication for installation and running costs.

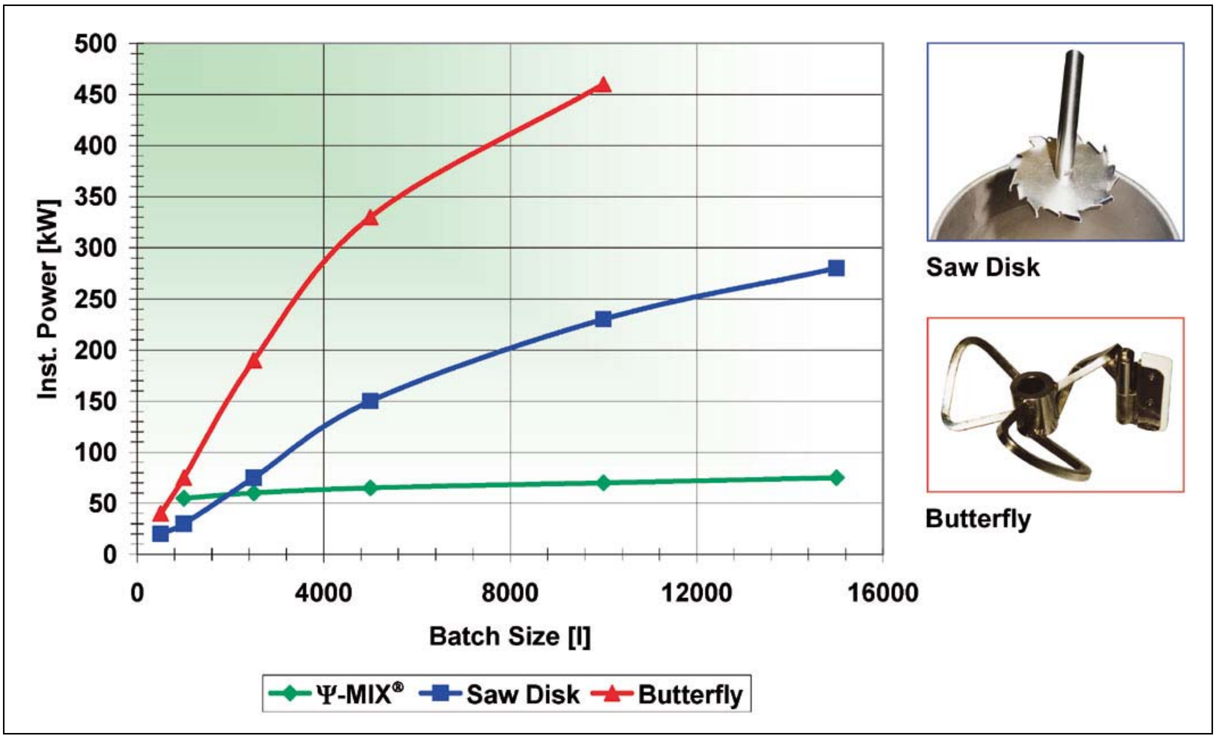

Figure 2: Comparison of different dispersing systems

The energy input on the Ψ-MIX® relates only to the powder feeding time. The volumetric dosing rate of up to 5 m³/h together with the bulk density of the dry components results in the batch time. Additional rework, in most cases, is not necessary.

Most methods are based on producing wet agglomerates, which should be broken apart by mechanical energy input via rotation. One of the problems with conventional technology is the broad size distribution of the agglomerated particles initially produced by the wetting process, from 10 microns (µm) to 2.0 mm and more. The request for more dust-free and process reliable powder handling leads to granulates and palletised raw materials, which is not supporting the basic of wetting micronized primary particles at all.

This wide distribution of dry agglomerates (*Figure 3*) results in an obvious difference in the required specific energy input to achieve a specific degree of dispersion. Considering the processes that may follow, i.e. fine grinding (fine dispersion) on bead mills, the energetic differences inherent in the type of pre-dispersion process become even more obvious.

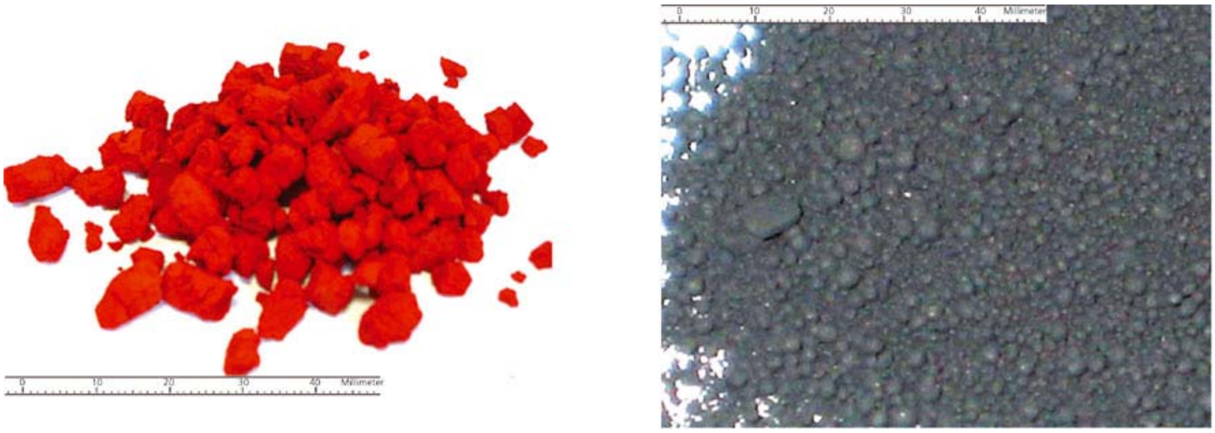

Figure 3: Granulated and beaded conditions

The efficiency factor of the pre-dispersion process could be found in connection to the subsequent process which is e.g. bead milling. When using a system like the Ψ-MIX® the milling time is considerably reduced by far more than 50% compared to a conventional mixing system like a HS-Disk (*Figure 4*).

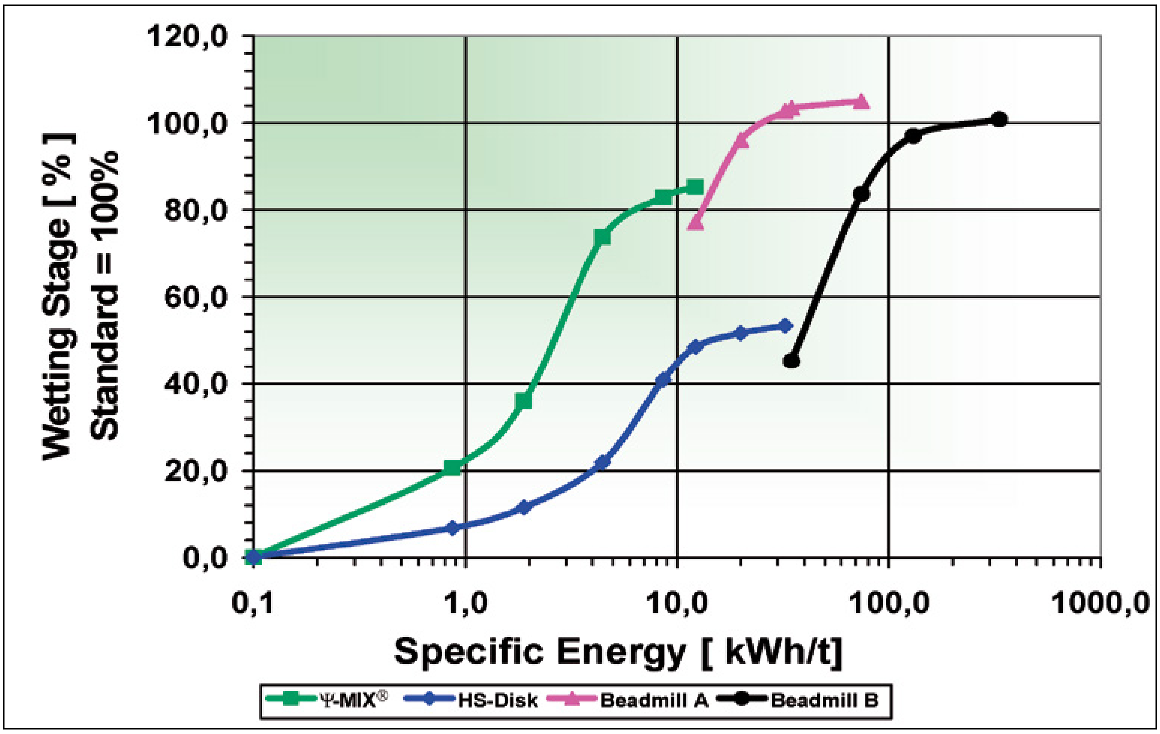

Figure 4: Specific energy comparison

Example:

- Conventional System: $E_{HS\text{-}Disk}$ 70 kWh/t + $E_{BM\ B}$ 180 kWh/t = 250 kWh/t
- Ψ-MIX® System: $E_{\Psi\text{-}MIX®}$ 10kWh/t + $E_{BM\ A}$ 90 kWh/t = 100 kWh/t

The combination of the Ψ-MIX® process with the bead mill process (BM A or BM B) shows significant energy savings which result in half installed power or machinery. The total calculation is complete if maintenance and cooling systems are taken into consideration, too. The new process is very soft to the pigments in use and it is expected to develop new quality standards in the future.

Background of the Ψ-MIX®

The advantages of in-line processing of solids into liquids are well known. What is new on this machine is the treatment of the solids and liquids during initial wetting. The solid material is no longer just dumped into the liquid phase, but is now atomized under dry conditions before being shot into the liquid.

A design criterion was the controlled formation of wet agglomerates, with the aim of an "optimum dispersion", i.e. to achieve the required degree of dispersion. In contrast, one could define an "ideal dispersion" where every primary particle is completely wetted. In most cases, the ideal dispersion is not the same as the quality specification, i.e. the required degree of dispersion or fineness of grinding that has been developed by conventional methods.

One problem for an effective wetting process is the quantity of micro air included in the charge of solid components. This air is inherent in the dry agglomerates. When the dry agglomerate is immersed into the liquid, the capillary path on the exterior of the particle is filled, sealing the interior of the dry agglomerate. In the core, an air pocket is created that stops the wetting process.

High shearing speeds break apart these stable, wet agglomerates (*Figure 5*) and new dry solid surfaces are released. Sub-level vacuum feeding or the condensation principle with gas exchange can be an acceptable solution to this problem.

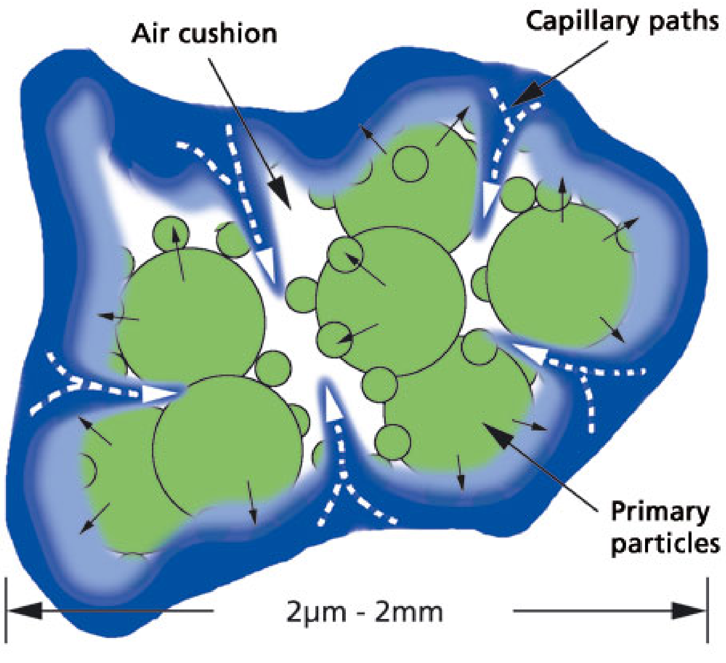

Figure 5: Wet agglomerate

The Ψ-MIX® Dispersion Technology

By connecting the individual process stages within a small space, all processes required for an optimum dispersion can be achieved within milliseconds.

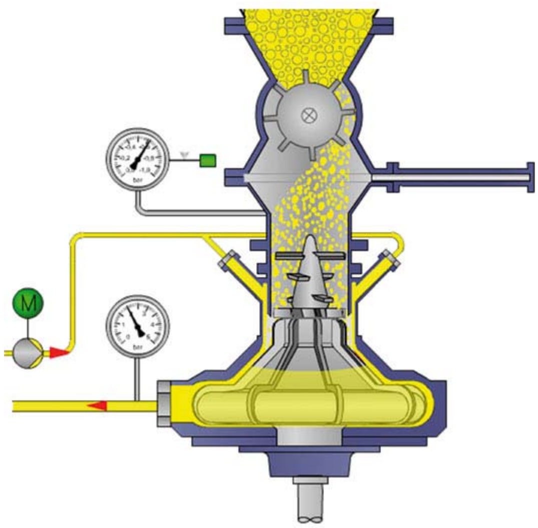

Figure 6: Function principle of the Ψ-MIX®

Figure 6 shows details of the process. The rotary valve attached to the solids feeding station seals off the dispersion chamber from the atmosphere and serves for dosing the powder. In the feeding tunnel that is under vacuum, the dry agglomerate is deaerated and fed to the atomizer. The vacuum is produced by a hydro cyclone effect, similar in concept to a liquid ring vacuum pump. The pump transports a liquid stream tangentially to a ring-shaped acceleration chamber where it is hydraulically accelerated into rotation.

The rotation corresponds approximately to the speed of the rotor, which prevents the liquid from splashing into the solids feeding tunnel. A “free-falling liquid curtain” is created and levelled by centrifugal forces. After about 100 mm, this liquid layer merges with the rotor, forming a seal and is discharged at high speed. The finely atomized solids falling from above are put into rotation by the rotor and spun towards the outside onto the liquid layer. Wetting occurs during the immersion of the individual solids and is assisted by the immediate increase in pressure. At the discharge of the machine, wetting is already perfect and cannot be improved by further processing with a disperser. The necessary rotary motion of the rotor leads to slight shearing, but this is negligible due to the wide gap between the rotor and the housing. These are also the reasons for the low induced specific power input of this invention. Micro cavitation occurs in a rapid transition from vacuum vapour phase to process overpressure, further improving the dispersion process. A further aspect for the optimum wetting process is the quickly flowing liquid surface, which is available with a surface of more than two square meters per second. The high liquid surface in relation to the specific surface of the atomized solid agglomerates provides an explanation of the basic principle of the Ψ-MIX®.

Continuous dosing of liquids and solids on the one hand or batch circulation with continuous powder feed on the other hand is possible. Because of quality control reasons the batch circulation is the most favoured method.

The machine can be used for a great variety of applications

Both machines, the *MICRO* Ψ-MIX® and Ψ-MIX® show their real strength for processing products with a high solid content, with a low solid portion in large liquid batches, with difficult wetting solids and with extremely fine solids. Temperature sensitive products as well as low to high viscosity – barely pumpable – suspensions of the entire field of application for dispersing technology can be processed. *Table 2* shows some examples.

Table 2: Applications

• Liquid Inks	• Industrial Paints	• Mineral slurries
• Paste Inks	• Automotive Paints	• Reactive slurries
• Ink-jet Inks	• Matting paste and fillers	• Chemical suspensions
• High viscosity extenders	• High load dispersions	• Ceramic slurries
• Usage of granulate	• Plastisol based suspensions	• Nano size suspensions
• Usage of resin chips	• Fumed silica slurries	• Food product
• UV systems both liquid and paste	• Nano size suspensions	• Life Science products

Summary

Innovative dispersion technology sets new benchmarks for modern production processes in all fields where micronized, pulverized solids have to be mixed as fine and as homogenously as possible. If the impression within the industry is that the development of dispersion technology has reached a standstill, the invention of the Ψ-MIX® shows promise for the future. It may be difficult to fully integrate the concept of this new invention, but from a technical point of view there are no objections. This new concept may raise some conflicts with conventional mixing systems. For established dispersion systems, it may define a new era in the market for dispersing equipment, and manufacturers of mills will need to make adaptations to accommodate the higher throughput rates. This concept should prompt one to do some rethinking about the dispersion process and to look at an innovative dispersion technology.