Optimizing the Mixing of Powders Into Liquids – Dust-free Induction and Dispersion

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Introduction

One would think that the mixing of powders into liquids should be relatively easy. You pour the powder onto the surface of the liquid, and then you mix it in. However, in actuality, the mixing of powders into liquids can be quite troublesome in the production environment. This paper will examine the various factors involved with mixing powders into liquids and how to avoid potential problems.

The first issue to consider in the mixing of powders into liquids is the dust created. Pouring powders onto the liquid creates significant dust if the pouring process is not done within a contained environment. The dust escaping into the work environment puts workers at risk for respiratory issues and possible explosions, as well as creates significant product waste. Dust accumulates below and on the vessel, and on surfaces throughout the production area, rather than becoming part of the final product. As a result, maintaining a clean work environment becomes more costly and the existence of excess dust throughout the production area can contribute to catastrophic secondary explosions.

Another issue arises when knives and other equipment are used to cut open bags or sacks prior to adding the powder to the liquid. Often these knives and other equipment fall into the mixing vessel, contaminating the production process and damaging valuable factory equipment.

Finally, throughout the mixing process, powder will stick to the vessel walls and other internal vessel parts. This is quite normal, but leads to the build-up of lumps and agglomerates when the powder comes in contact with the liquid. Under normal production, it takes a long time and strong shear to break and disperse these lumps and agglomerates, adding to production costs and time to complete the process.

To avoid these production issues inherent in the mixing of powders into liquids, there are several process options to consider.

Dust- and Loss-free Powder Induction

The induction of powder into the liquid is the first mixing process to improve. One wants to minimize any powder loss via dust and other waste occurring during the powder transfer by using a transport and dispersing (TDS) system that inducts powder dust- and loss-free directly from a bag into the liquid. In such a system, no bag has to be lifted on top of the tank or to a filling tray. This process avoids any product loss or dust escaping into the work environment, as well as minimizes worker injuries.

In actuality, when powder is inducted out of the bag directly into the mixing vessel via a TDS system, no dust appears even around the bag. The airflow created outside of the bag by the vacuum transfer of the powder from the bag to the vessel maintains the dust within the vacuum during the entire induction process. As a result, the storage bags are completely emptied and no powder is wasted. By the same token, if just a part of the powder in the bag is required for the process, the bag may be placed on a scale and the required amount of powder can be dosed exactly via the vacuum process.

This method of powder induction by a TDS system has proven extremely beneficial in those cases where dusty, dirty and harmful powders such as black carbon, pigments, silica or Diatomaceous earth have to be mixed into low viscous liquids. TDS systems eliminate the risk of fine dusts (dusts with a particle size below 10 µm) from escaping into the work environment, alleviating concerns about operator safety when working with such potentially hazardous materials. Although maximum permissible exposure limits are provided in ppm for powders, it can be impossible to adhere to these limits when pouring powders into an open vessel. With TDS systems, the only minimal dust that may occur is when the full bag is opened or when the empty bag is compacted, greatly reducing risk and associated liability.

Different from any conventional powder transporting or conveying system, TDS machines do not require any additional air for fluidization or transportation. No filters, no dust extraction and no additional equipment are necessary to produce the vacuum and no knives or other devices are inadvertently swept into the mixing process. Models installed outside the vessel are able to induct powders dust-free from bags, hoppers, containers, bulk bags or silos into a liquid.

Powder Wetting and Dispersion Without Agglomeration

TDS systems offer the additional advantage of wetting and dispersing the powder without causing agglomeration. The powder is wetted either below the liquid surface or inline in a self-circulated external loop. As a result, the powder is dispersed immediately with no agglomeration. No dust sticks to the wall of the vessel whether it is a standard or expensive vessel.

The TDS system is built on a vertical mixing process that results in higher homogeneity compared to other stirrer systems. In a vertical mixing process, the mixing head consists of a rotation hyperboloid-shaped guiding tube known as the stator. In the center of the stator, a fast turning impeller rotates and forces a strong stream of liquid downwards to the bottom of the vessel. On the bottom, the stream is redirected along the wall of the vessel upwards until it reaches the surface of the liquid. Finally, it moves back to the mixing head. In this way the complete content of the vessel is vertically circulated and homogeneously mixed. This mixing principle is particularly effective with solid-liquid blends, because the solid typically tends to sediment at the bottom of the vessel. A vertical mixer totally avoids this sedimentation.

The TDS induction mixer combines this vertical mixing process with a strong vacuum in the center of a fast rotating rotor. This vacuum is used to induct powder material into the liquid, typically using an induction tube and hose. The powder is completely wetted by the mixing head below the surface of the liquid. Because of the enormous turbulences in the fast rotating rotor, there is an immediate and intensive micro mixing of powder and liquid together. No dust escapes the liquid. No powder sticks on the shaft of the mixer, on the wall of the vessel or on devices inside. No crusts or agglomerates are given the opportunity to develop.

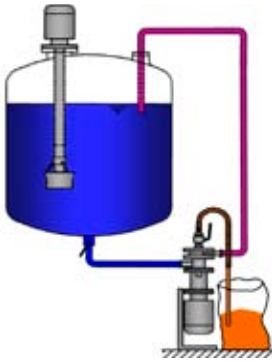
TDS induction mixers work inside the mixing vessel and may be used for a wide range of products; however, the viscosity of the basic liquid may not exceed 1000 mPas. Thickeners or sticky powders cannot be inducted with this machine, the filling level in the vessel must follow certain conditions and the maximum length of the machine is limited.

Products Benefitting from TDS Processing

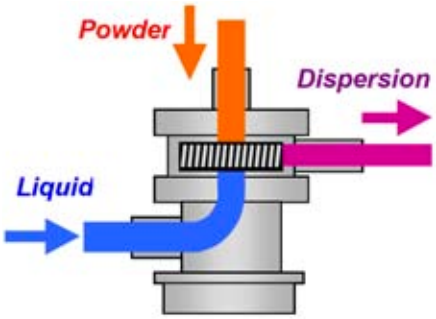
As a result of its induction and wetting process, the TDS brings greater production efficiencies, less operator risk and higher final product quality as indicated by the following examples of products that could cause serious health risks if not handled properly.

- **Highly dispersed Silica acid**
  TDS machines handle highly dispersed Silica acids – such as Aerosil, Cab-O-Sil, and HDK, among others – with great efficiency. The powder is easily fluidized and inducted into the liquid directly from a bag. No dust is created during the induction, protecting the operator and work environment from these toxic chemicals. The direct induction results in a very short wetting and suspending time with a high degree of dispersion, avoiding additional dispersion with a shear ring.
- **Filter aid (Diatomaceous earth)**
  Diatomaceous earth is a filtering aid that is being used for the filtration of drinks with a high concentration of solid particles. In powdery form, this powder is dangerous. When it comes into the respiratory system, it could cause Silicosis or Silico-Tuberculosis. A dangerous concentration of dust arises when Diatomaceous earth is being added manually into a dosing system or into a suspension vessel. With the TDS system, the Diatomaceous earth is inducted directly from the bag into the liquid, where it is completely wetted and dispersed - no dust comes out of the surface of the liquid.
- **Activated charcoal**
  Activated charcoal is being used for filtering purposes as well as for water and wastewater treatment plants. It is very dusty and can quickly pollute the environment and working areas due to the high concentration of dust it exudes to the air when processed. Using a TDS system eliminates this problem.

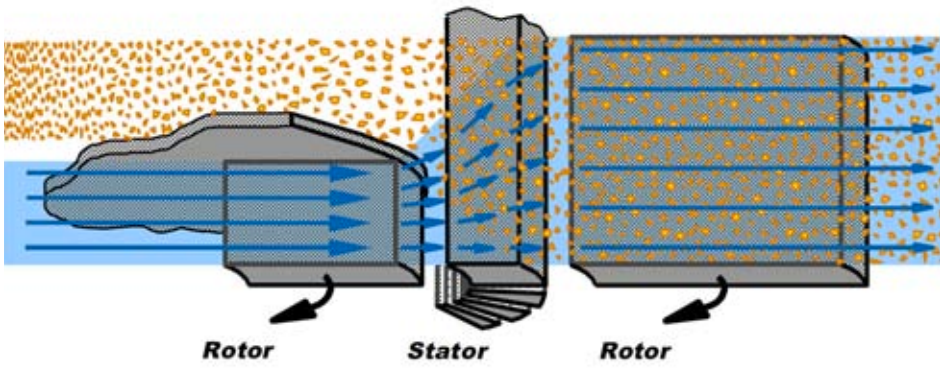
Even the Finest Powders Are Completely Wetted Immediately



Installation of the Conti-TDS

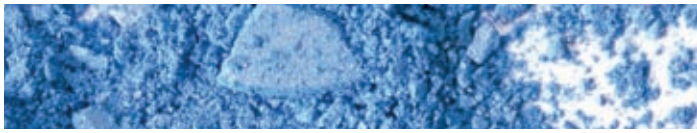


Powder and liquid are mixed in the dispersing chamber



Wetting and dispersing zone of the Conti-TDS

Entry into the dispersing chamber • Vacuum increases • Air between particles expands • Distance between particles increases • Particles are accelerated	Dispersing zone • Between rotor and stator high-shear dispersion under vacuum • In this phase, maximum vacuum, maximum distance between particles • Specific surface of the liquid is enlarged a million times • Every single particle is wetted and dispersed completely	Exit from the dispersing chamber • Maximum pressure • Minimum distance between particles • Air is compressed • Coagulation of the air bubbles



The powder restrictions of the inside-mounted TDS system can be overcome by working with a Conti-TDS induction system that can be installed outside the vessel via pipes or flexible hoses. This version offers an inline dispersing machine producing a stronger induction vacuum in its dispersing zone, allowing it to work with any viscosity that can be pumped, including sticky powders. For extremely high viscosity products such as offset printing inks, silicon sealants, knifing filler or glue, the machine is used in combination with a volumetric pump.

With the patented Conti-TDS, powder and liquid reach the mixing chamber on completely separate paths, avoiding any contact with each other before they reach the dispersing zone. This is important to note as when fast swelling powders are inducted, any contact with liquid prior to the dispersing zone would result in the powder swelling and not reaching the dispersion zone at all. In the dispersing zone, powder and liquid are dispersed under vacuum with the strongest turbulences possible and a very high shear rate. As a result, even the finest powder particles are immediately and completely wetted.

This process results in dispersion quality and solid concentrations not possible using traditional or conventional mixing such as with dissolver or mixer. This is quickly evident in a comparison of the shear gradient as shown in Table 1.

Table 1: Conti-TDS Shear Gradient in Comparison with Stirrers and Dissolvers

	Conti-TDS	Stirrer	Dissolver
Shear Gradient (The quotient of shear speed and the gap in-between the shear rings)	50.000 s^{1} 1000 times higher than Dissolver	20 s^{-1}	50 s-1

Manufacturers looking to improve production efficiencies can improve their process speed with the Conti-TDS as well. With horsepower rates ranging from 10hp to a maximum of 350hp, induction rates can reach values of almost 1000 lb./min. when inducting calcium carbonate or sugar from a bulk bag. This is in comparison to other machines in the industry offering 20 and 75 hp and inducting powder between 20 and 200 lb. per minute.

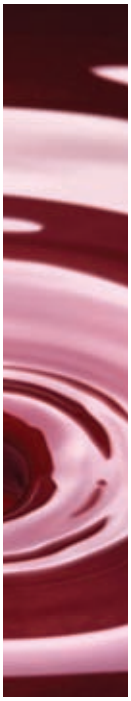
Installation and Versatility Lead to Greater Efficiencies

The Conti-TDS system is installed outside the vessel where it can work independently from the size or the filling level of the vessel. It can easily be positioned so that bag handling and transportation can be minimized and the lifting of bags to a platform is eliminated by its built-in vacuum system. The machine integrates into existing processing plants easily. Modifications of buildings, vessels or process equipment are normally not required as the machine can be operated in a vertical or horizontal set-up to fit available footprints within existing operations. Liquid connections can be adapted to the on-site situation as well.

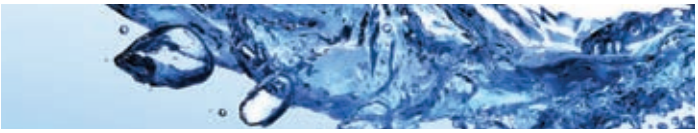
The Conti-TDS is a versatile machine allowing customization to the individual process. It can be equipped with a variety of powder inlets and dispersing tools. When shear-sensitive products are being processed, the stator can be easily removed and powder inducted into the liquid without any appreciable shear effect. The system can handle low and medium viscosity products on its own; no additional pump is required. For this reason, the Conti-TDS may be used as a transfer pump to the next processing step as well. Additional pumps are not required. Only when inducting into a high viscous liquid, such as knifing fillers, adhesives, offset printing ink, seal or similar compounds, a volumetric positive pump is installed at the liquid outlet of the machine.

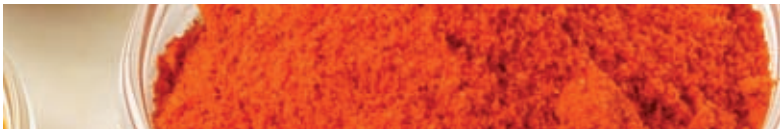
The system allows several powders to be inducted and dosed in a machine-controlled sequence, greatly expanding a production line capability. Dosing is independent of operator influence, thereby maintaining a constant induction rate so important in producing lacquers, cleaning gels, detergents or cosmetic products. Swelling and dispersing time can also be adjusted. De-aeration is easily handled.

The Conti-TDS can also handle more than one vessel and, as an outside mount, can be placed on casters and moved from one mixing operation to another. These capabilities lead to production time and cost efficiencies allowing integration into existing processing systems or creation of a continuous process using two vessels working in flip-flop, a combination of batch and storage tank or as a min/max processing system. Similar to a pump, the machine circulates the liquid by itself in a loop.



Powder induction from bulk bags in two process vessels with one Conti-TDS





After powder induction, the powder valve closes and the Conti-TDS operates as an effective inline dispersing machine until the required particle size distribution, homogeneity or consistency is achieved.

The TDS principle is not restricted to just powder. The same machine can be used for the mixing and dispersion of “non-mixable” liquids (oil and water) or of liquids with total different viscosities. Because the low viscous liquid tends to stay on top of the high viscous liquid for a long time, a normal mixer or stirrer cannot mix it in. On the other hand, high viscous liquids are difficult to distribute in low viscous fluids because the mixer is designed for low viscosities. In both cases the Conti-TDS provides a continuous dispersion and the liquids are already homogenously mixed when they reach the vessel.

Process unit with Conti-TDS for variable batch sizes

Conti-TDS with pump for extremely high viscous materials

Avoiding the Dangers of Mixing Powder into Inflammable Liquids

Its ability to provide agglomerate-free powder induction, wetting and dispersion within one process not only improves product quality and offers production efficiencies, but the Conti-TDS can also greatly impact plant and operator safety. A case in point is mixing powder into inflammable liquids.

The addition of powder into an open vessel containing inflammable liquids (solvents) is very dangerous. It is well known that not the liquid, but the vapor on top of the liquid, is flammable. When one pours powder, which always contains air (this important fact is often forgotten), into the liquid it could produce an igniting spark due to static electricity in the powder. Just a spark with low energy is now sufficient to ignite the air-containing solvent vapor.

When using a Conti-TDS machine for this process, the powder is not poured into the vessel with the solvent vapor on top. It is inducted directly into the circulating liquid by the vacuum in the mixing head. As the powder is inducted directly under the liquid surface, the air (and therefore, oxygen) is not added to the solvent vapor mixture, and an air/solvent vapor mixture is not created. The risk of igniting this mixture is thereby eliminated.

About Powder Technologies, Incorporated

Powder Technologies, Incorporated brings together the most experienced, highly regarded processing equipment manufacturers in the world with a proven commitment to design and fabrication to solve processing application requirements while improving production and profitability. They offer equipment design and fabrication for size reduction, screening and classifying, mixing, and feeding equipment for dry bulk processing and powder inducting, wetting and dispersing systems to handle a wide range of applications. The equipment discussed in this whitepaper is manufactured by YSTRAL.

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