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Dispersing without Destroying

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abstract

In home and personal care products, many hydrocolloids are used as thickeners and rheological additives. When mixed into liquids, initially agglomerates are created, which then have to be broken down again through dispersing. However, most of these polymers are shear sensitive, especially after hydration. Dispersing destroys the gel structure already formed and breaks down the desired viscosity. This problem can be solved with a process that separates the primary particles of the polymer powder before they get in contact with the liquid, then individually wets and disperses them immediately, thereby hydrating them without agglomerates – using the vacuum-expansions process. It is based on the fact that a powerful vacuum is generated directly in the liquid. The polymer is therefore added under maximum vacuum. In this way, the polymer particles are disagglomerated before wetting. No further dispersion is required. Agglomerates are not created. Using the vacuum expansion process, the maximum effect can be achieved with a reduced concentration of hydrocolloids. Viscosity, thixotropy index, transparency, film formation and wetting behaviour, as well as many other properties this way will achieve a level not possible previously. A subsequent uncontrolled thickening through inorganic thickeners, such as smectite or other layered mineral silicates is ruled out.

Functionality must be Ensured

Thickeners and stabilisers are designed to give the end product an optimum flow behaviour and an ideal viscosity, not only in respect of the subsequent application, but also during storage and shelf life. Cleaning agents or disinfectants must not simply run off from a surface but instead they have to form a defined film on the surface. This is the only way the cleaning agent works properly. Shampoos or gels have to have a pleasant rheology and gel solidity after dosing. Stabilisers also prevent the product separating and components of the recipe from forming sediment or floating during shelf life.

Agglomerates have to be Prevented

Thickeners and stabilisers are coming as dry powders. Because of their strong thickening effect, they are used in low concentrations. To achieve maximum viscosity, they require a colloidal exposure in the liquid phase. High-molecular hydrocolloids increase the viscosity. The higher-molecular they are, the more shear sensitive they are as well, even during processing. However, difficulties during processing are also connected with the specific properties of these powders. Mostly they create dust, stick and form fine agglomerates or even larger lumps. In industry small gel lumps are often called fisheyes because they are clear as glass and form a slimy, smooth surface. It is extremely difficult to break up these fisheyes again. This is why they should generally be avoided.

Hydrocolloid powders float on the liquid surface after addition because of their low bulk density and are difficult to stir in. If they are drawn down from the surface at high stirring

speed as a result of the forming vortex, air always enters the product as well. This air is undesired because it can only be removed again with difficulty. But external addition through injectors, inline blenders or suction via a vacuum vessel is also problematic because conventional systems of this type initially always generate agglomerates.

Shearing May Cause Irreversible Damage

When lumps and agglomerates are created, they have to be broken down again. Typically, they are dispersed under high shear until all lumps have been destroyed. With most powders, the hydration starts directly upon first contact with the water. They cause polymer structures that are sensitive to shear and form gels. From the moment of powder addition, the liquid should no longer be dispersed because this would irreversibly destroy the structures already created. Texture and viscosity are broken down.

Previously, there was only one possibility for compensating for this loss of effect: A higher concentration of hydrocolloids had to be used. This increases the costs, but without improving the quality for the end consumer. Indeed, uncontrollable fluctuations in product quality are the consequence. The flow behaviour and the functionality of the product are unpleasant for the user if there is excessive use of thickeners, the appearance and thus also the image of the product suffer. Product management and marketing typically develop extremely concrete requirements as to how final products should look like or flow. These have to be fulfilled precisely and quality-assured in production.

The causes of the entire problem chain are always powder agglomerates, which form when the hydrocolloid is added to the liquid, and the hydrated gel already formed is damaged during the subsequent dispersion. The powder addition therefore has to be applied in a way, in which no agglomerates form and in which additional dispersing does not have to be performed. The vacuum expansion method takes advantage of some special physical properties of the powders.

This is how the Vacuum Expansion Method with the Conti-TDS Works

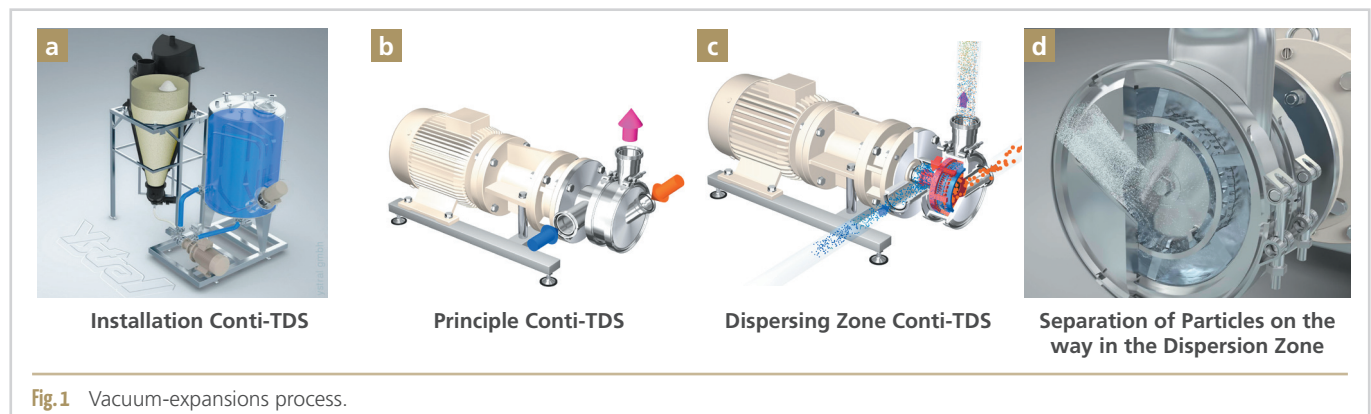
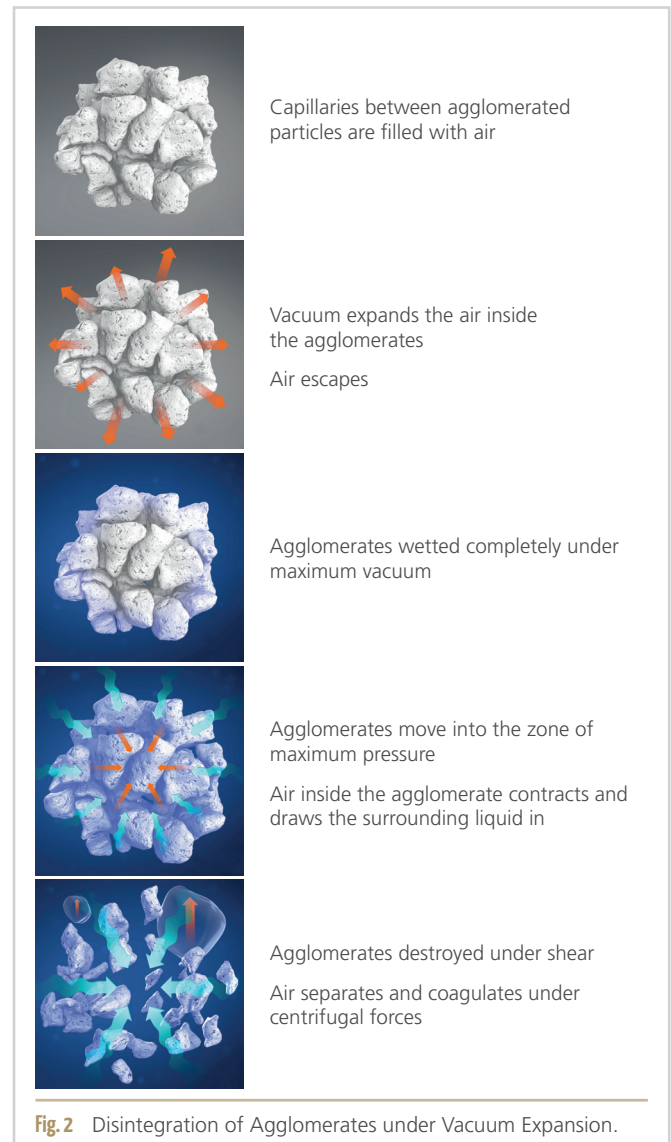
Powders consist of individual particles, which are touching each other. However, there is air between these particles. The volume of air enlarges under vacuum, i.e. the air between the particles expands. The distances between the particles increase. As a result, the particles are separated. The nearer the powder comes to the zone of maximum vacuum, the greater the distances between the particles. No extra air is added for this. The air already in the powder merely expands. This effect can only be used in a powder flowing at high speed and under an increasing vacuum.

It is precisely this effect that the Ystral Conti-TDS uses when adding powder and dispersing by vacuum. The machine transports and disperses powders directly into liquids (Fig. 1a & b). For this, it generates an extremely powerful vacuum in its dispersing zone. The powder is inducted precisely into this area (Fig. 1c). The closer the powder comes to the dispersing zone, the greater the vacuum and the faster the powder flows, and therefore the wider the distances between the individual particles (Fig. 1d). In the dispersing zone, the powder particles get into contact with the liquid under maximum turbulence and are completely wetted individually and are colloidally dispersed. Agglomerates are not created, and further dispersing is not required either.

At the moment of wetting, the powder is not yet hydrated and thus is not yet sensitive to shear. Maximum dispersing is desired and required at this moment, but not afterwards, not even in a directly downstream dispersing stage or dispersing machine. The Conti-TDS wets and disperses *in situ* under vacuum during the passage through the dispersing and wetting zone. This wetting and dispersing process takes just fractions of seconds.

Wetting from Inside

Dry agglomerated powders with capillary structures inside are even internally fully wetted in this way. This is also the case for porous powders with internal capillary structures such as silica gel (Fig. 2). This is because these internal structures and capillaries are also filled with air in their initial state. The air inside expands as they approach the dispersing zone under



maximum vacuum – but without disintegrating the agglomerate already at this moment. The complete wetting from outside finally takes place under maximum vacuum. The agglomerate, which is now surrounded completely by liquid, is moving with the liquid out of the zone of maximum vacuum and maximum dispersing directly into the surrounding zone of maximum overpressure and strongest centrifugal forces. The air inside the capillary volumes implodes under the external overpressure and draws the surrounding liquid inwards. Agglomerates disintegrate and collapse in this way because of the simultaneous dispersing. Porous powders with internal structures are wetted completely from inside.

The air previously in the powder and now released coagulates under the centrifugal effect of the high speed rotation to form large air bubbles and is transported together with the liquid to the process tank, where it escapes through the surface of the liquid. The process is characterised by a particularly gentle but also particularly fast dispersing and maximum exploitation of the powdery ingredients. It is used with great success in the production of shampoos, lotions and all other liquid or gel products, whether these are personal care products or cleaning agents

Integration into Existing Plants

The Conti-TDS is the best solution for complete dispersing. This machine can be integrated easily into existing plants. Mostly the machine is simply connected to the existing process tank in order to realise the addition of powder. As the vacuum is generated directly in the Conti-TDS, this can be a simple atmospheric mixing tank without any vacuum (**Fig. 3**). One interesting method is to use the machine already during filling liquid into the process tank. Several companies use this inline variant in the production of highly viscous toilet cleaners, toothpaste or gels. Even if the use of the products is very different, there are parallels in the production process. With the Conti-TDS, the thickener is added, dispersed and activated completely inline during the filling of the tank. The process ends as soon as the liquid has reached the tank. The finished product can actually be pumped out again immediately. Using this inline method, even very highly concentrated gels can

be generated with up to ten percent xanthan gum, cellulose ether or guar gum. In a batch process this is absolutely impossible because just seconds after powder addition the viscosity is far too high for further processing or powder addition.

Of course, it is also possible to connect the Conti-TDS to a separate side pot to produce concentrated thickener solutions. The thickeners and other components are mixed and dissolved there in an optimum sequence. They are added to the main process tank as a concentrate.

In the production of detergents, the trend is moving from batch processes to complete inline production. The Conti-TDS can also be integrated into the inline mixing processes. However, this mostly does not take place directly in the main stream because powder contains an uncontrollable amount of air which has to be removed completely. For that reason, it is typically realised as continually air free concentrate production in a side stream.

Hydrocolloids have Different Requirements

When processing thickeners and stabilisers the very different swelling mechanisms of the individual hydrocolloids have to be taken into account. There are variable rotor-stator tools, controlled powder inlets and specific procedures available for this. All thickeners have to be inducted with their specific induction speed to avoid local over concentration. But that's not all. Every Thickener has different further requirements. Carbomers, for example, have to be intensively sheared directly when adding the powder, then the neutralisation takes place. They get extremely shear sensitive and are irreversibly destroyed if there is any shearing. Cellulose ethers, on the other hand, are dispersed immediately after addition of powder with reduced shear rates, until the viscosity has been completely developed. This process is completed already after just around five minutes when using the vacuum expansion dispersion. In conventional agitators it takes hours. Dispersers destroy the texture. Xanthan gum has to be dispersed intensively immediately after powder addition. The machine is then switched off for several minutes. Hydration takes place without shear. Sustained shearing does not accelerate the process



Induction with suction tube



System with separate powder hoppers for powders with different behaviours



One Conti-TDS with two process tanks

Fig. 3 Integration of Conti-TDS into existing or new plants.

but instead only destroys the gel. After around ten minutes the machine is switched on again briefly at a high shearing power. This generates the maximum viscosity, the highest possible thixotropy and a perfectly smooth gel structure.

Mineral sheet silicates, as for example smectites as inorganic thickeners, are among the most difficult media to process in the production of cosmetics and cleaning products. Standard processes fail to separate the individual lamellae of the silicates entirely from each other. Incompletely separated sheet silicates cause subsequent thickening in the bottle or container. Previously products containing sheet silicates were therefore stored temporarily for a few days before filling in order to prevent subsequent thickening. The product was only filled when the thickening was largely complete. However, this takes time, of course, and requires additional storage capacity. Using the vacuum expansion method, the sheet silicate lamellae are completely separated directly when being added to the liquid. This results in no further thickening during shelf life. A useful side effect is a higher viscosity compared to the previous process because of complete dispersion, as a result of which the concentration of thickener can be reduced when using the Conti-TDS. Up to three process steps previously had to be performed in different tanks when using hot swelling starches as thickeners. First of all, a cold starch suspension with a reduced liquid quantity is produced. A larger quantity of hot liquid is prepared in the main process tank. The cold suspension is stirred in slowly and the mix is kept at cooking temperature for a defined period. This phase then typically has to be diluted

in the same or in a third tank with a correspondingly large quantity of cold liquid to the required final concentration and the correct temperature. Using Conti-TDS the process can be realised considerably more efficiently in just one single tank. The list can be continued as desired. There are several dozen different thickeners with individual mechanisms. No problems with agglomerates or blocking, constant quality and efficient control are main benefits of the dispersion under vacuum expansion method.

This Makes the Conti-TDS so Flexible

The Conti-TDS is designed in such a way that the choice of the thickeners used is irrelevant. The machine can be adjusted easily to the respective circumstances. Easily changeable tool-kits are available – comprising rotor, stator and specific powder inlet – for the various different applications. All other powdery components, not just thickeners, can also be added very quickly and effectively. This system is already in use around the world in the production of various home and personal care products and over time has therefore almost been perfected.

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