Ystral®
110% MIXING SOLUTIONS

WHITEPAPER

Optimization in process technology

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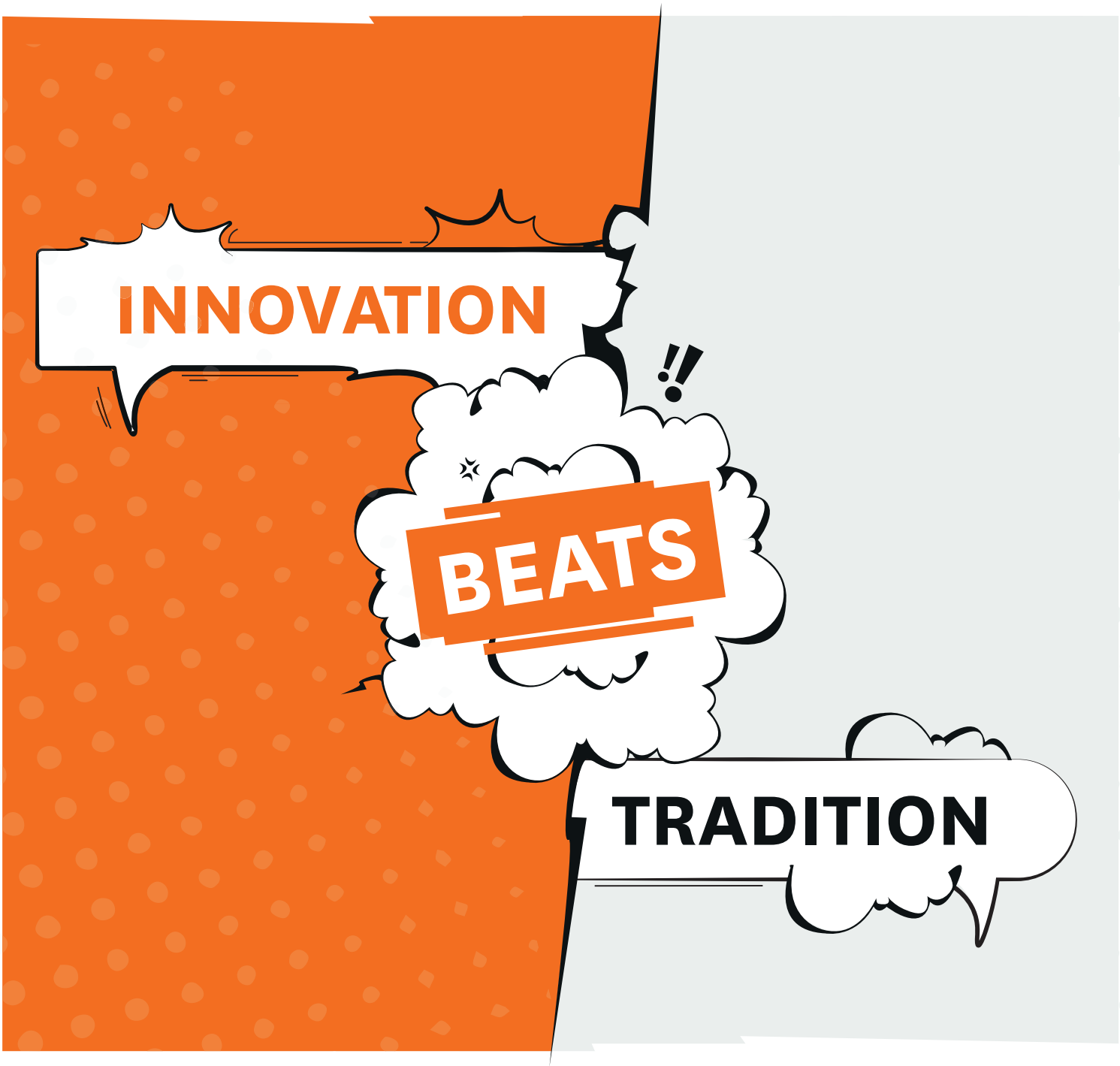
More flexibility, safety, quality



Innovation instead of tradition – a central topic in process technology

"Well-tried" production methods and technologies in process engineering thwart us. It might be tempting to operate machines and systems as long as they still function, but it is not effective – and if an existing system is replaced or extended with precisely the same "proven" technology, the issue is prolonged by several years.

Innovation and process optimisation enable companies to operate more efficiently, cost-effectively and more environmentally friendly. However, often, the innovative and process-related methods and solutions are not even known. Even though they are always associated with simplifications and cost savings. If the possibilities are not even known, their potential cannot be utilised either.

Therefore, in this Whitepaper, we would like to take a closer look at some areas in which significant advantages can be achieved with innovative solutions compared to traditional processes.

Innovation is not an option in process technology, but a necessity.

At ystral, we have developed machines and methods which **drastically reduce process times** – for some applications even by more than 99 %. How can this work? For example, by increasing the volume-specific capacity by factor 30,000 – but not increasing the energy used in doing so, but rather reducing it by 60 %. Or by replacing random and undirected processes with targeted innovative processes. At the same time, the content of a vessel can be stirred for 30 minutes or longer in a circular motion, and still not be homogeneous. The inertia of the vertical liquid hinders vertical circulation. Or a consistently vertical mixing principle is used, i.e. a jetstream mixer, and **everything is homogeneously mixed in less than 3 minutes.**

Future-proof solutions

The aspects of flexibility, safety and quality are also discussed in this Whitepaper. Continually new provisions, safety regulations and quality requirements are the order of the day in the process industry. This powder must no longer be added openly, this additive has undesirable side effects. Preservatives must only be used at minimum quantities. And hybrid mixtures may no longer be processed with the available machines at all. The continuous compliance with new provisions can be difficult for companies. It takes time, resources and training to ensure that all employees are up to date. The solution in these cases again is an innovative technology, which is flexible and safe – not only today, but also in future.

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Mixing instead of stirring

Traditional technologies in process engineering such as agitators and high speed dissolvers are not well suited as tools for homogeneous mixing, the differences in effectiveness compared to innovative mixing technologies are significant. By using technologies from ystral, process times can be cut by up to 90% depending on the application.

Fig. 1: *Innovative mixing technologies enable enormous efficiency gains, for example in the production of paints and varnishes. Image: Wellnhofer Designs - stock.adobe.com*

"Stirring" or "Agitation" is of crucial importance in many areas of the process industry. Stirring is a necessity to mix different components with each other, or to prevent disintegration, sedimentation or flotation of recipe components, in short, to achieve homogeneity and prevent separation.

Agitation is also necessary to heat and cool the contents of the vessel and to equalize the temperature. Melting, gassing, crystallizing, precipitating, and – up to a certain level - even dispersing and emulsifying, are also tasks for an agitator. For all these basic tasks, special emphasis is always on **homogeneous mixing of the vessel content.**

In the majority of cases, agitators are used for homogeneous mixing – the differences between traditional agitators and innovative mixing technologies are significant here.

There are also agitators that are to hinder homogeneous mixing in a targeted way. This is necessary for reaction columns in which an ingredient is added at the very top or a gas at the very bottom, which is then slowly distributed through the vessel, level by level, with as long a residence time as possible in each individual layer. For this purpose, disc agitators or dissolver discs are used, which produce a consistently tangential rather than axial flow. There are even agitators for segregation, degassing and phase separation.

However, in the majority of cases, agitators are used for homogeneous mixing – and for this, the differences between traditional agitators used in various areas of the industry and innovative mixing technologies are immense. With state-of-the-art jetstream mixers, the process time compared to traditional agitators can be drastically reduced.

Halving of the batch time with a more effective mixer alone

Tab. 1 shows an example for a process sequence with the individual steps

CONVENTIONAL AGITATOR | **PROCESS TIME (MIN.)**												
20	10	30	10	20	20	40	10	20	45	45	45	45
Filling water	Dosing components / Stirring	Dissolving under Stirring	Acid addition / pH adjustment	Stirring until homogenous /	Addition PAS under stirring	Stirring until agglomerate free & fully hydrolyzed	Caustic addition / Neutralization under stirring	Dosing color under stirring	Dosing active ingredients /	Stirring until homogenous	Lab test	Viscosity & pH adjustment / Stirring	Final Lab test / Release

Tab. 1: *Process steps and times when using a conventional agitator. The total batch time is 360 minutes, the effective stirring time is 250 minutes (areas marked orange).*

Fig. 2: *Jetstream mixers can be installed on the vessel wall, the ground or the vessel ceiling. Image: ystral*

such as dosing, dissolving, setting the pH value, dissolving polymers, neutralising as well as quality control and viscosity setting. The complete process so far has taken 360 minutes. This makes just one batch per shift possible. If double the quantity is to be produced, a second system is needed for this, amongst others with the respective control and process technology.

But there is another way.

In this 360-minute process sequence, the effective stirring time is 250 minutes (s. areas marked in orange in Tab. 1) – which is where the potential for reducing the process time can be found. Stirring also occurs in the areas shown in black, but water is added during these times, laboratory measurement is performed or a release is expected. These times cannot be shortened with a more effective agitator.

Up to ten times faster homogeneous mixing with innovative mixing technology

However, during stirring times, significant reductions in process time can be achieved by using innovative technologies, because in the periods shown in orange, complete dissolution, hydrolisation, neutralisation and homogeneity must first be completed before the next step can be initiated. Due to its vertical circulation, the YSTRAL jetstream mixer (s. Fig. 2) can mix the vessel content homogeneously up to ten times faster than a conventional agitator. In the example shown, the time needed is shortened to 90 minutes, which corresponds to only 25 % of the previous stirring time. Depending on the process, savings of 60 to 90 % are possible.

As illustrated in Tab. 2., every process step of the stirring process previously lasting 250 minutes was reduced, every single stirring and dissolution time is now shorter. The entire batch time reduces to 200 minutes. Due to this, instead of one batch, two batches per shift can be completed – only by using a more efficient mixer. Thus, no new system is required for doubling the production capacity, but simply a new mixer.

An even greater process time reduction is possible when a jetstream mixer integrated into the vessel is combined with a mixer or disperser operated outside of the vessel in the circuit. In the above example, the batch time

JETSTREAM MIXER | **PROCESS TIME (MIN.)**												
20	5	10	5	5	10	15	5	5	15	45	15	45
Filling water	Dosing components / Mixing	Dissolving under Mixing	Acid addition / Mixing	Mixing until homogenous / pH adjustment	Addition PAS under mixing	Mixing until agglomerate free & fully hydrolyzed	Caustic addition / Neutralization under mixing	Dosing color under mixing	Dosing active ingredients /	Mixing until homogenous	Lab test	Viscosity & pH adjustment / Mixing	Final Lab test / Release

Tab. 2: *Batch time reductions from 360 to 200 minutes with a more effective mixer.*

is reduced to 120 minutes with this, which means instead of one batch, three batches can be completed per shift (more information on this can be found in section "*Realising intensive processes outside instead of inside the vessel*", p. 8-9).

Circulation in the vessel being far too slow

A typical issue of most agitators is that circulation in the vessel is far too slow, which significantly slows down the process. **Often, the liquid merely rotates – just like in a carousel.** However, this horizontal rotation is not the circulation required for homogeneous mixing. What is needed, in actual fact, is circulation from bottom to top, from top to bottom, from inside to outside and from outside to inside.

What is needed for homogeneous mixing is circulation from bottom to top, from top to bottom, from inside to outside and from outside to inside.

When using a conventional agitator, vertical circulation of the vessel contents only takes place very slowly - and if you want to mix more or less homogeneously, at least 10 circulations are required. If, for example, a tinting paste is then added to the liquid surface for mixing, this must also be done very slowly, over several cycles, so that it doesn't create a local over-concentration, which again significantly increases the process time.

Such slow product circulation might be acceptable in a storage tank, but not in a process vessel or a let-down tank. Often, media with completely different flow behaviours are mixed in a process vessel: viscous and low-viscosity media, light and heavy liquids or gases or powders into liquid receivers. Everything may be able to circle at the top of the vessel, but not so further down in the vessel. Light and heavy liquids make completely separate movements, they are even separated from each other. To pull powder from the surface into a liquid, the agitator has to be accelerated so fast, that a vortex is created, which pulls an uncontrolled amount of additional air into the liquid.

Baffles generate non-mixable zones

Adding to this, the horizontal circulation of the liquid represents a safety risk. It may indeed be the case that vessels charge up in a way that the vessel platform is torn from its mounting in the wall. Baffles need to be installed to prevent this from happening. However, these generate flow shades and non-mixable zones. They are also difficult to clean.

High dependency on the fill level

Another problem is that a traditional agitator (shown in fig. 3 with three propellers) can only be used effectively in a very limited filling level range. In areas where the fill level is only slightly above a propeller, a strong vortex would be generated if power is too high, and large quantities of air would be introduced into the process. To prevent this, the speed of the agitator must be reduced in these areas. In the red areas, the agitator cannot be used at all due to the so-called

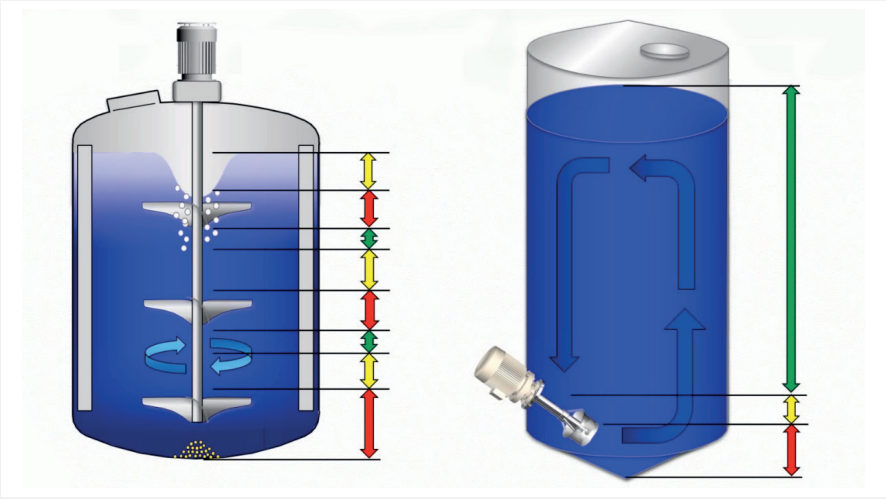

Fig. 3: *For an YSTRAL jetstream mixer, the fill level range with which the machine can be operated at full capacity (green marking) is significantly greater than that for a traditional agitator. Image: ystral*

pass-through operation. This means that in case of decreasing or increasing fill level, which is always found in processes, such an agitator must be switched off when the propeller burbles on the surface – otherwise, it might soar upwards and destroy the bearings.

High flexibility and homogeneous mixing results with the YSTRAL jetstream mixer

On the other hand, when using state-of-the-art jetstream mixers, the fill level range in which the machine can be operated at full power (s. green section in Fig. 3, in the yellow section, use of the jetstream mixer is limited, in the red area it cannot be used at all) is significantly increased, which means processes can be designed very flexibly.

Jetstream mixers from ystral focus on process intensification and a local concentration of the machine capacity by combining a turbulent micro-mixing zone in their mixing head with an almost turbulence-free vertical macro-mixing of the entire vessel content. Other than when using a conventional agitator, the product is actually fully mixed homogeneously at the end of the mixing process – without any unmixed zones and sediments – and consistent results are achieved independent of the batch size and the fill level in the vessel.

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Notable gains in efficiency when switching from dissolver technology

The dissolver, which is widespread in the production of varnishes and paints, is not very effective as mixing tool either. The dissolver technology goes back to the 1930s, and has only changed slightly in past decades (s. Fig. 4). The dissolver disc is used for mixing, dispersing and inducing powdered raw materials in the liquid at the same time. The disc only generates a very low shear effect, thus requiring high viscosities for dispersing, which counteracts effective powder induction. The principle of the disc stirrer hinders vertical mixing. The powder induction by means of vortex introduces a lot of air into the product, which not only reduces the dispersion effect, but also necessitates the use of additives, which have a negative effect on the finished product at a later stage. So with a high speed dissolver, mixing and dispersing occurs with a tool which is not suitable for mixing or intensive dispersing.

When switching from traditional dissolver technology to innovative mixing and dispersion technologies, enormous gains in efficiency are possible.

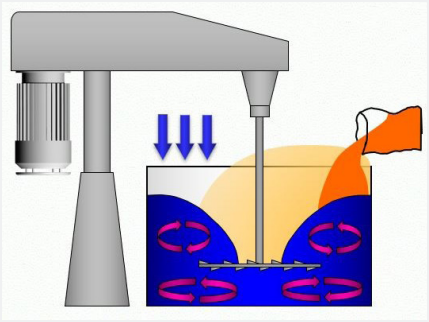

Fig. 4: *The dissolver technology common in the paint and coatings industry goes back to the 1930s, and has changed very little in the past decades. Image: ystral*

For example, a car paint manufacturer previously dispersed 5,000 litres of paint in the high speed dissolver over 5 hours. By using the vacuum expansion technology for dispersing with the YSTRAL Conti-TDS dispersing machine, this process was reduced to below 30 minutes. The energy requirement is far below 10%. Intermediate storage is never necessary for this method, post-thickening has been abolished. The layered silicates even develop higher viscosities than ever before, and their proportion in percent can thus be reduced.

With a high speed dissolver, mixing and dispersing occurs with a tool which is not suitable for mixing or intensive dispersing.

Realising intensive processes outside instead of inside the vessel

In traditional process technology, many processes take place in the vessel – this includes intensive processes such as dispersing. However, intensive processes are much more effective outside the vessel, and the process parameters can be controlled better. Versatile process options can be realised with technologies from ystral.

Fig. 5: *A manufacturer of oat drinks has dramatically reduced process times by producing a highly concentrated premix with subsequent dilution in the main process vessel..Image: Frederico di Campo – stock.adobe.com*

Much more effective than mixing, the induction of powdered raw materials in the liquid and dispersing with a single tool within the vessel is realising the two performance-intensive processes of powder wetting and dispersion outside the vessel. In the vessel itself then only a homogeneous mixture is needed, which can be efficiently realised by using a jetstream mixer. It is also possible to precisely control the dwell time of the product in the intensive dispersing zone this way. This is impossible inside the vessel.

Powder wetting and dispersion with the vacuum expansion method

The inline powder wetting and dispersion technology from ystral based on the vacuum expansion method utilises the compressibility of the air under pressure and its expansion under vacuum to separate powder particles and break them up colloidally. A strong vacuum directly in the wetting and dispersing zone expands the volume of the air contained in the powder by a multiple, which causes the distance between the particles to increase significantly (s. Fig. 6). The particles are separated and fluidised.

The YSTRAL Conti-TDS powder wetting and dispersing machine (s. Fig. 7) generates a liquid surface in its wetting zone of more than one million square metres per minute. This is more than the powder surface to be wetted and approx. 10,000 times as much compared to a high speed dissolver. Powder and liquid only come into contact with each other in the wetting chamber – under maximum vacuum

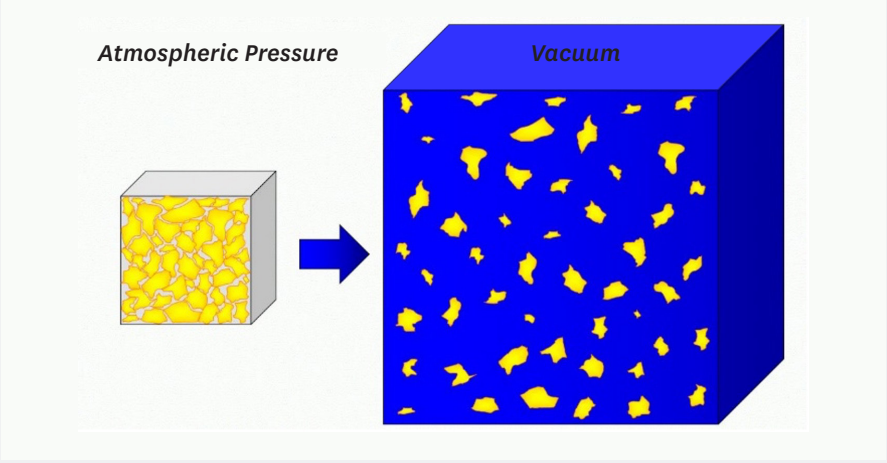

Fig. 6: *The vacuum expansion method utilises the compressibility of the air under pressure and its expansion under vacuum to separate powder particles and break them up colloidally. Image: ystral*

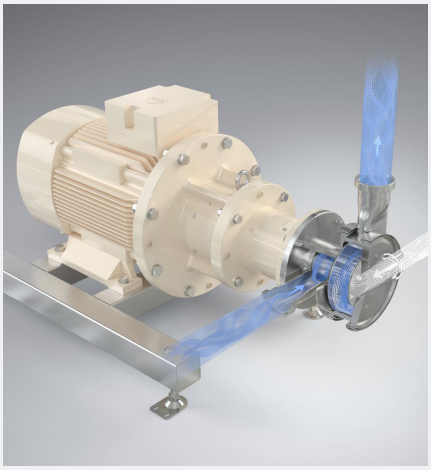

Fig. 7: *The inline powder wetting and dispersing machine YSTRAL Conti-TDS. Image: ystral*

and maximum turbulence. The powder particles have the largest possible distance to each other in the dispersing zone, and can thus be fully wetted and dispersed individually.

While the capacity of a dissolver is distributed over the entire vessel content, with the YSTRAL Conti-TDS, the processes of wetting and dispersing are concentrated in one dispersing zone with an effective volume of only approx. one quarter of a litre. Compared to a High Speed Dissolver operated inside the vessel, a Conti-TDS thus generates an approx. 20,000 times higher volume-specific power. This concentrated capacity is crucial for the dispersion result.

Versatile process options

The options for the realisation of processes outside the vessel are extremely versatile with technologies from ystral. Processes can be realised inline (also see section "*Inline instead of batch*", p. 21) or in the circuit (for one simple circulation process, see Fig. 8).

Fig. 9 shows a plant with two different dispersing machines installed outside the vessel. While the right machine in the circulation process is used for the dispersion of powders, the left machine is used for emulsifying liquid components. In both cases, the intensive dispersing processes now take place outside the vessels.

Furthermore, in food production, allergenic and non-allergenic powders can be absorbed completely separately and processed in separate liquid circuits. It is also possible to create a highly concentrated premix in a small process vessel, which is later diluted in several main process vessels.

Process time reduction by producing a highly concentrated premix

This option is used by a manufacturer of oat drinks, for whom ystral has realised two complete process systems. A highly concentrated powder dispersion is produced in a small process vessel with a capacity of just 6,500 litres with the YSTRAL Conti-TDS connected in the circuit. This takes approx. 15 minutes. This solution is then pumped into a main process vessel holding 60,000 litres, whilst it is still being filled with water. An YSTRAL jetstream mixer is installed in the small as well as large process vessel, which homogeneously mixes the entire content in the vessel. This means the entire mixing process is already completed once the large process vessel is completely filled. The user wanted to reduce the process time starting at this point for the powder induction and dispersion from two hours to one hour. In actual fact, the process is now already completed – the process time for these process steps was thus reduced by 100 % compared to the previously used solution.

Process time reduction for powder induction and dispersion by 100 %

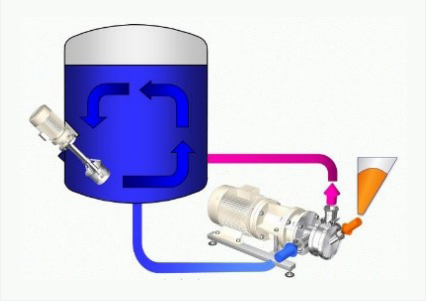

Fig. 8: *Circulation process with YSTRAL Conti-TDS and process vessel with installed YSTRAL jetstream mixer. Image: ystral*

Fig. 9: *Plant with two dispersing machines outside the vessels: On the left, an inline dispersing machine for the production of emulsions, on the right, a Conti-TDS for the processing of powders. Image: ystral*

Fig. 10: In wall paints, an average of 8% titanium dioxide can be saved by keeping colour strength and opacity the same. Image: TwilightArtPictures – stock.adobe.com

Resource efficiency instead of resource waste

Innovative solutions in process technology enable a significantly more effective utilisation of resources. Powdered raw materials can be better utilised with a colloidal particle breakdown. The space requirement is significantly lower. Furthermore, new processes save on average two-thirds of the energy required when using conventional technology.

Technologies from ystral enable raw material savings with at the same time higher quality of the end product. Two examples of this are the processing of titanium dioxide in the production of varnishes and paints and the processing of thickeners and stabilisers in yoghurt or dessert.

Example titanium dioxide

With a proportion of almost 60 % of all pigments, titanium dioxide is by far the most important pigment in the manufacturing of lacquers, paints and inks. Depending on the titanium dioxide content in a paint, up to 50 % of the raw material costs could be generated by this raw material alone. Main target is to achieve the same quality of the paint, measurable in colour strength, chromaticity and opacity, but with less titanium dioxide. This is possible by using the Conti-TDS with its inline dispersion technology.

The effect of titanium dioxide is based on its extraordinarily high refractive index. Titanium dioxide particles are smaller than the wavelength of visible light. Therefore, they are scattering all the light waves up to a certain distance from their particle surface. This so-called influence sphere is considerably greater than the individual particle itself because of the larger light wavelength. This means that only a reduced number of particles, with spaces between them, is needed for a completely white and completely covering coating.

Fig. 11 shows that two particles with a distance that is larger than three times their diameters will double the light scattering. Smaller gaps are a disadvantage. Agglomerated particles have the least effect. The influence sphere of multiple agglomerated particles is only insignificantly greater than that of a single particle. Agglomerated particles reduce the colour strength and opacity. As a result, a significant part of the used titanium dioxide has not any effect.

Main target is to achieve the same quality of the paint, measurable in colour strength, chromaticity and opacity, but with less titanium dioxide.

The problem is that titanium dioxide has a strong tendency to agglomerate. The process-relevant goal, therefore,

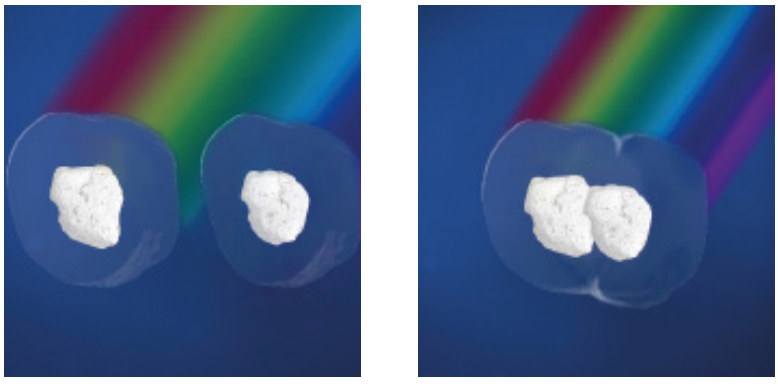

Fig. 11: Influence sphere and light scattering on titanium dioxide particles. Sufficient distance doubles the scattering capacity. Image: ystral

Fig. 12: *Thickeners in yoghurt or dessert are required for the creation of a creamy mouthfeel. However, many thickeners also mask the taste – thus, less thickener means a more intensive taste. Image: AngrySun – stock.adobe.com*

is to separate the particles consistently and then to stabilise them in the right distance to each other. This is done in the Conti-TDS through high shear dispersion in combination with vacuum expansion. At the same time, dispersing additives are dosed and stabilize the distances. In wall paints, an average of eight percent titanium dioxide could be saved by keeping colour strength and opacity the same. In printing inks the concentration could be reduced even more. These are considerable raw material savings.

Thickeners and stabilisers

Thickeners and stabilisers in yoghurt or dessert are required for their stability, for creating a creamy mouthfeel, and for preventing the whey permeability, i.e. the sedimentation of a clear liquid on the yoghurt. However, many thickeners also mask the taste – thus, less thickener here means a more intensive taste.

If these thickeners and stabilisers are mixed into the liquid base using agitators, injectors or blenders as commonly found in the food industry, clumps and agglomerates are initially formed. These either have to be broken down through dispersion or just filtered out. Unfortunately, dispersion irreversibly destroys the shear-sensitive, already hydrated gel. Filtering causes an uncontrolled loss of thickener. As a result, a considerably larger quantity of thickener has to be used in the recipe in order to achieve the desired texture.

By using the YSTRAL Conti-TDS powder wetting and dispersing machine, the thickeners are broken down without agglomerates. Redispersion is not necessary. The texture is not destroyed. The proportion of thickener is thus reduced by about one third on average. This not only saves some hundred thousand Euro per year, but the quality and acceptance of the end products is also higher.

By using the YSTRAL Conti-TDS powder wetting and dispersing machine, the proportion of thickener can be reduced by approx. one third on average in the production of yoghurts and desserts.

Low space requirement

In many companies, the spacial possibilities are limited, which makes the available space a crucial resource. This highlights a decisive disadvantage of the limited productivity of many existing process plants. Existing “proven” and established technologies are often rather slow. Especially mixing and agitation steps take far too long. The entire plant is blocked for hours. In order to increase capacity based again on these established technologies, additional plants are needed, and soon the available space is used up.

And it is not only the space for the additional plant itself: The area required for buffering raw materials, for collecting empty containers, the transport paths for forklifts, the space in the control centre and in the electrical control room is also mostly used up. Typically, there is not enough air available and the compressed air network is not designed for double capacity. This means an additional plant creates far more resource problems than just the additional space needed for the plant itself.

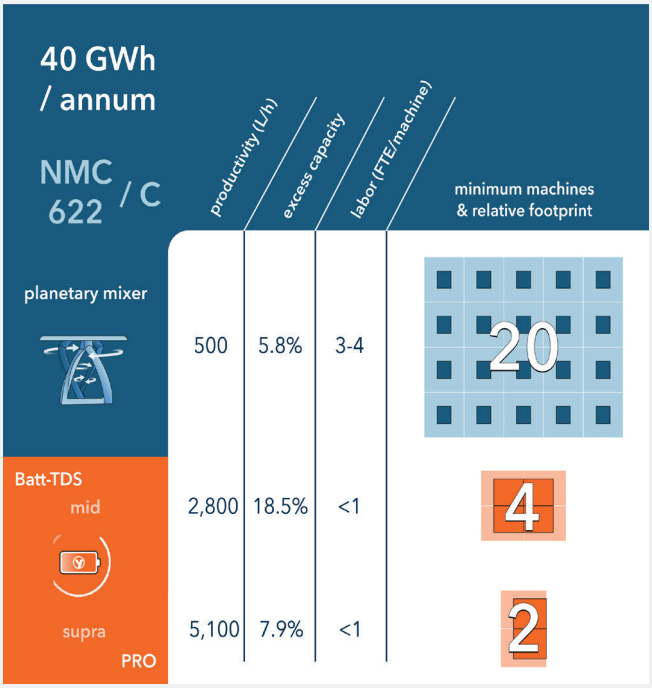

Fig. 13: *Productivity and space requirement of planetary mixers as well as the YSTRAL Batt-TDS Pro systems mid and supra in comparison. Image: ystral*

Fig. 14: *The YSTRAL Batt-TDS Pro supra production system for the production of cathode or anode slurries enables batch sizes of up to 10,000 litres and thus replaces 10 planetary mixers. Image: ystral*

It often makes more sense to disassemble an ineffective system and replace it with faster technology. But powder wetting machines or mixers from ystral are often also integrated into existing systems, to increase their capacity with little effort (also refer to section "*Integration of new technologies instead of 'Continue as before*", p. 22-23).

Drastically decreased system footprint in the production of battery slurries

One example for the considerably decreased space requirement when using innovative technology is the production of lithium-ion-electrode slurries. The production of battery slurries with traditional technologies is not only energy-intensive and slow, but also associated with an enormous space requirement. The Batt-TDS technology developed by ystral for the production of lithium-ion-electrode slurries inducts powders dust-free under vacuum into a liquid stream, thereby enabling dispersion of the powder particles within milliseconds. At the production scale, the new technology achieves a more than 10 times higher productivity compared to conventional planetary mixers, and a productivity that is twice as high compared to available extruders. Fig. 13 shows a comparison of conventional planetary mixers and the Batt-TDS Pro systems mid and supra for the production of electrode slurries at the scale of currently planned factories (40 GWh / year), illustrated for NMC 622/ graphite batteries with regard to space requirement and productivity.

Often, when selecting machines, the reduction of electrical power is confused with the saving of energy.

Energy requirement

New processes save on average two-thirds of the energy. Unfortunately saving energy often is confused with saving power – which is not the same. There are providers advertising agitators with a low power number (Ne-number). Such a low power requirement is always based on an almost turbulence-free laminar flow in the vessel. Without turbulence all the liquid can be moved with minimum electrical power and a small motor. But is this positive for mixing processes? If you add, for example, some red and blue paste to such an agitated vessel filled with white paint, red and blue stripes will still be visible even after an hour of stirring. That is not mixing. This is just moving liquid. To get homogeneity it takes ages.

To mix two or more media, you need turbulence. But not everywhere inside the vessel – that would be a huge waste of energy. Jetstream mixers are ideal, since they combine a local turbulent micro-mixing zone inside the small mixing head with an almost turbulence-free laminar macro mixing movement in the rest of the vessel. Because of the local turbulence,

jetstream mixers need more power, up to two times more than a simple agitator. But they need less than a tenth of the time until complete homogeneity. Energy is the product of power and time. The total energy requirement is less than a third despite the higher power.

When **heating or cooling** in a process vessel, a vertical liquid movement downwards or upwards along the cooled or heated tank wall is mandatory. Agitators, that generate predominantly horizontal rotation, don't exchange the liquid at the wall fast enough. They achieve only limited heat transfer compared to vertically circulating jetstream mixers. Heating or cooling with jetstream mixers in the tank needs just a fraction of the time and thus less energy as well.

Fig. 15: *Space-saving process plant for thickener solution production. Image: ystral*

Flexible instead of rigid process technology

Manufacturers must be able to produce a large number of product versions and newly developed products. Whilst with a rigid design, machines and plants must be replaced completely in case of a process change, with modular systems, selective adaptations are sufficient to tailor a machine or plant to changed requirements.

Fig. 16: *For big globally acting producers of fast moving consumer goods ystral offers a special concept with machines that can be adjusted to local conditions and future tasks with minimum changes. Image: Martina Misar – stock.adobe.com*

A key property of ystral machines and plants is their flexibility. Users have to react to customer demands and changes in the market. Batch sizes, formulations and even the processes themselves must be variable.

Processes, raw materials and final products may change. New raw materials or additives are used. Older shear resistant additives are replaced by new ones that are very shear sensitive. Or the opposite: the new ingredients have to be treated significantly more intensive. Very often the initiative comes from the purchasing department because it has succeeded in getting much cheaper raw material, unfortunately often with a coarser grain or stronger agglomerated. Now it has to be dispersed much harder. Ultimately, the final customer asks to get improved qualities. Quality demands are constantly increasing.

Subsequent conversion or extension involves enormous costs

No reason to refit the plants for every additional task or to change the machines every time. Subsequent modification mean engineering costs and production stops during refitting. New pipes, cables and instrumentations would have to be installed, new safety inspections and certificates are required. Extensions to the existing controls are necessary. The follow-up costs are very high. Forward-thinking planning, convertibility, flexibility and future orientation are, therefore, important aspects when planning and deciding investments. ystral is setting trends especially for those requirements with easily convertible multi-purpose machines, multi-functional inline machines and flexible plants.

High flexibility on machine level

Smaller ystral machines up to 7.5 kW, which are typically operated on a lift, are equipped with completely interchangeable shafts. These interchangeable shafts are designed such that the mixer shaft is enclosed in a permanent steel pipe. There is no risk of an accident when touching this shaft, unlike to agitators or dissolvers with open rotating shafts.

Depending on the task, the interchangeable shafts can be fitted with different tools. Changing the shaft takes just seconds. Jetstream mixer tools are used for the complete, homogeneous mixing and suspending. They generate a vertical circulation without rotation of the liquid, without any baffles inside the tank. For intensive dispersion, on the other hand, dispersion heads are used. They operate according to the rotor-stator principle and reduce particle or drop sizes in suspensions or emulsions.

Dispersing and mixing with one machine

The YSTRAL Dispermix and the YSTRAL High Shear Dispermix are combinations of disperser and mixer.

Fig. 17: *ystral multipurpose machine with shafts on the lift. Image: ystral*

In addition, there is an interchangeable shaft with a TDS induction mixer for the induction of powders into liquid as well.

Inline machines installed outside the tank, either in line or in a pipe loop, must be as flexible as possible, multi-functional and easy to refit as well. Powder wetting machines of type Conti-TDS have the primary task of inducting powder dust-free into the liquid and dispersing it at the same time. For applications without powder induction there are tools available that allow the powder wetting machine to be converted in just a few moments into a high shear dispersion machine with shear gradients of up to 100,000 s-1. The conversion is very easy: only two screws have to be removed and two components replaced.

For big globally acting producers of fast moving consumer goods ystral offers a special concept. These companies guarantee identical product qualities around the world, even if batch sizes, technical requirements and locally applicable standards may vary. To achieve this, **identical machines are required globally**. These machines must have maximum flexibility so that they can be adjusted to local conditions and future tasks with minimum changes.

ystral has developed basic machines, which can be operated globally in all electricity networks and under all applicable standards. The machine execution is tailored to the largest possible product range. However, as it is never possible to manufacture different product groups with just one single machine, there are sets of tool kits to adopt it quick and easily. These tool kits consist of three to four parts only. The machines are interchangeable globally between the locations. The spare parts are also identical. This flexible modular concept has proved successfully.

Maximum flexibility also on system level

Not only machines, even complete systems require maximum flexibility. A wood coating manufacturer, for example, produced more than 400 formulas in a wide range of qualities and batch sizes on customers demand in two factories. More than 20 dissolvers in different sizes are used, hundreds of transportable tanks. The labour costs are high. The entire production can be realised in just two Conti-TDS double tank plants. One Conti-TDS is installed between two vessels and works automatically. The liquid feed, the powder feed and the controls are only needed once for both systems.

The special feature of these double tank plants is that both process vessels can have completely different sizes. As a result, batch sizes from 100 to 3,000 litres can be produced in each system; an extremely wide spectrum. The cleaning is fully automatic. The two plants cover the complete bandwidth of recipes and batch sizes, transparent, white and coloured. None of the previously used dissolvers is needed any longer.

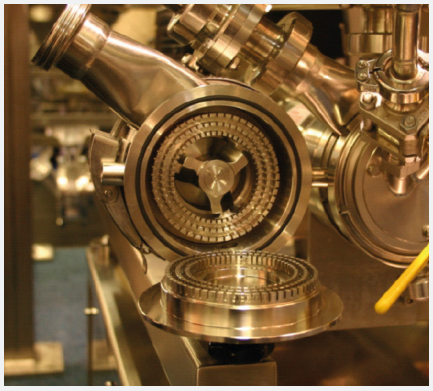

Fig. 18: *Rotor and stator for refitting the YSTRAL Conti-TDS into a high shear dispersion machine with shear speeds of up to 50 m/s. Image: ystral*

Fig. 19: *Globally used YSTRAL Conti-TDS comprising the basic machine and an installed tool kit for manufacturing dairy desserts. Image: ystral*

Fig. 20: *Flexible double tank plant based on Conti-TDS for producing batch sizes of 100 to 3,000 litres. Image: ystral*

Continuously high product quality instead of faulty batches and rework

The manufacturing of products with constant and maximum quality should be a matter of course, but it isn't always. Two main issues are insufficient technology and too much variation in the processes. With ystral technologies, in contrast, a consistently high product quality is achieved.

Fig. 21: *A user can apply copper- and biocide-free antifouling coatings for nets in industrial fish farming thanks to ystral technology without undesirable foaming in the product. Image: Werner - stock.adobe.com*

Due to the vertical circulation of the entire contents of the vessel, jetstream mixers not only provide a faster, but also a significantly more homogeneous mixture. The results are remarkable, for example, in car manufacturing. Paint spraying robots are sensitive to minimum differences in viscosity, composition and consistency of the sprayed paint. Deviations will cause visible failures. The paint quality must remain consistent from begin when the storage tank is full to the end when it is empty. Jetstream mixers are used in these vessels for homogenous mixing at every filling level.

Suspensions contain solid particles, which are heavier than the liquid and therefore they tend to sediment to the bottom of the tank. The jetstream mixer principle is ideal to prevent from sedimentation. Everything that even only has a tendency to sink down to the bottom is immediately fully mixed again.

During the induction of powders in liquids, fluctuations in quality are particularly large

With traditional technologies, there is a strong operator influence when adding powders to liquids. If powders are inducted in the liquid more quickly than they can be wetted, agglomerates are created initially, or even a floating layer of unwetted powder on the liquid. But not only the manual addition is problematic. Conventional methods like feeding from top, induction with vacuum from below or using conventional blenders or injectors in a loop have all the same problem: the powder surface to be wetted is more than a thousand times larger than the liquid surface available for wetting. This imbalance is the actual cause of clumps, agglomerates, and ultimately quality fluctuations.

To pull powder from the surface into a liquid, the agitator has to be accelerated so fast, that a vortex is created, which pulls an uncontrolled amount of additional air into the liquid as well. Air creates foam, reduces the mixing and minimises the dispersion effect. Agglomerates have to be broken down through long dispersing times. This damages the product and heats it unnecessarily. Serious problems are obvious in the production of lacquers, paints and inks in a dissolver. The measured quality is simply not constant. Each batch is different and varies in terms of viscosity, colour strength and particle size distribution. After each batch, the quality has to be checked, adjusted and checked again until the product can finally be released for further processing – an expensive process.

Ruling out operator influences, enlarging liquid surface

If you want to tackle the causes of quality fluctuations from the ground up, firstly the speed of powder addition has to be controlled independently of the operator, and secondly, the liquid surface available for wetting has to be increased extremely.

Precisely these two measures are performed when using the Conti-TDS. The operator has no influence on the induction speed. The machine determines the suction power. The powder wetting takes place with maximum turbulence precisely in the high-shear dispersion zone where the liquid surface is increased by more than ten thousand times. The product quality is consistent and reproducible.

Fig. 22: *Consistently high product quality with process technology from ystral. Image: ystral*

Adjustments are not necessary. The costs for quality checks are considerably reduced. Overall, the manufacturing process for lacquers, paints and inks has been completely revolutionised by the use of the Conti-TDS technology.

Innovative products frequently require an innovative process technology

Innovative products can often not be produced at the desired quality without innovative technologies. One example for this are innovative antifouling coatings for nets in industrial fish farms. Antifouling coatings reduce the growth of algae and other organisms on the nets, and are often still copper-based. For the fabrication of their newly developed copper- and biocide-free coating solutions, a user initially used high speed dissolvers, which they also used for their copper-based coatings. However, the company found that the use of conventional process technology resulted in quality deficiencies with the new coatings: The long process times in the high speed dissolver resulted in a strong, undesirable formation of foam in the product. This undesirable foaming could be counteracted by using defoamers, but only to a certain extent. Only when switching to technologies from ystral, the company managed to disperse the powdered raw materials in a gentler, more product-friendly way, not only overcoming the quality issues in doing so, but also tripling production capacity.

Fig. 23: *Jetstream mixers deliver a considerably more homogeneous mixture than traditional technologies. The results are visible, for example in automotive engineering, as paint splatter robots respond to minimal differences in the composition and consistency of the sprayed paint with visible differences in the varnish. Image: Ivan Traimak – stock.adobe.com*

Hygienic design instead of difficult cleanability

With machine and system versions in hygienic design and optimised cleaning processes, resources can be saved during cleaning, and system availability and product quality can be improved. ystral has developed different technical solutions for effective cleaning, and uses their experiences from the food or pharmaceutical industries for entirely different applications, such as the production of varnishes and paints.

Fig. 24: *ystral utilises their experiences from industries with very high hygiene requirements such as the pharmaceutical industry for completely different applications. Image: Alexander Raths – stock.adobe.com*

The rules of hygienic design aim for complete cleaning and emptying of a machine or plant with the lowest possible use of cleaning agents. ystral machines and plants are usually designed according to these rules: Every flange, every seal of a mixer or disperser has been designed in a way to enable easy and complete cleaning– without gaps, threads or hidden zones. Even areas such as the underside of a mixer flange can be cleaned without shadows by means of special cleaning heads.

Easy and complete cleanability – without gaps, threads or hidden zones

Disperser used as CIP pump

In order to render cleaning processes as easily as possible and limit the time needed for cleaning, ystral integrates CIP technology directly into the system, and the conveyor effect of the available machines is used for cleaning whenever possible – a separate pump is then no longer needed. An YSTRAL Conti-TDS dispersing machine operated in the circuit can thus not only be used for processes such as induction, wetting and dispersing of powders as well as pumping the complete product, but also for circulation of the cleaning medium. For GMP-suitable cleaning, the flow rate of the cleaning medium must be at least 1.5 m/s to prevent the formation of sediments and create sufficient turbulences. With ystral, independent of the size of the system, the flow rate is usually even 2 m/s.

ystral also uses the conveyor effect of the YSTRAL Conti-TDS disperser for its **tank cleaning machine TRM100**, which compared to other cleaning systems enables a significantly higher liquid throughput – up to more than 50 m³/h. The system has proven itself in practice, above all for circulation of cleaning liquid in vessel sizes between 5 m³ and 50 m³ as well as for users requiring high jet pressure for effective cleaning.

No surface drying of the product in the vessel

When powder is induced from the top into an open vessel, dust above the liquid on damp surfaces results in adhesions, powder crusts and contaminations on the vessel wall, cover, agitator shaft and all fittings in the vessel, the removal of which is time- and energy-intensive. However, in closed systems with powder induction below the liquid level, the cover space of the vessel can be kept largely clean.

Depending on the application, ystral also uses spray nozzles, for example to prevent water-based paints from

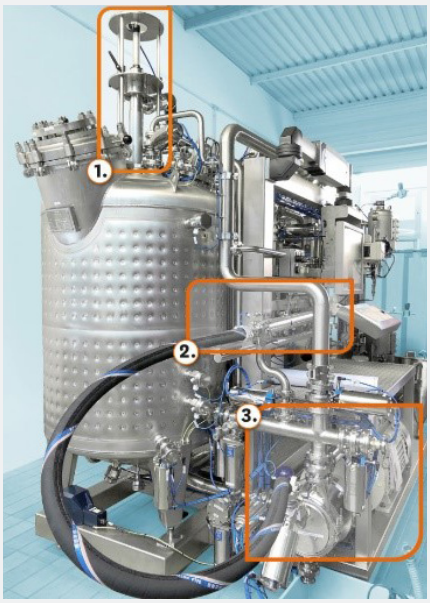

Fig. 25: *Process system from ystral with tank cleaning machine TRM100 (1), rinsing quiver for cleaning suction hoses (2) and the YSTRAL Conti-TDS disperser (3). Image: ystral*

Fig. 26: *Plant for manufacturing pigment pastes according to the principles of hygienic design. Image: ystral*

drying when pumping out the product. Such a nozzle is used to finely nebulise the main liquid component in the vessel, thus creating a humid atmosphere above the product to reliably prevent drying. This is not possible with an open process.

Cleaning concepts for the periphery

ystral also developed cleaning concepts for the system periphery with the powder and liquid handling and the cleaning of pump-out lines. For example, a specially designed rinsing quiver is used for cleaning suction hoses. This quiver enables the suction hose, which is contaminated with the raw material internally and externally, to be integrated into the CIP cleaning of the system in a connected state and thus be cleaned simply and quickly, secured by a clamping clip.

Experiences from the food and pharmaceutical sector applied to other industries

In terms of cleaning processes, ystral uses experiences from industries with very high hygiene requirements, such as the pharmaceutical or food industry, for applications in very different industries. Therefore, an ystral machine, which is used for the **production of paints and varnishes,** can be cleaned just as well and quickly as a machine for the production of baby food or pharmaceuticals.

Manufacturing of water-based products with significantly less use of biocides

The system shown in Fig. 26 for the production of pigment pastes produces highly concentrated colour pastes in white, red, yellow, black and any other colours one after the other. Cleaning takes place automatically when changing colours between the individual batches. The pipe connections are not the simple flanges usually found in chemical industry. These are aseptic connections, easy to clean, gap free flanges in hygienic design, as used in the food or pharmaceuticals industries. The surface quality of the product-facing metal surfaces is polished. Instead of sharp corners and edges, all the transitions are designed with curves that correspond to the principles of hygienic design. Retractable spray heads are used in the vessel. In this way, the user in the paint industry profits from ystral's range of experience in completely different industries. Colour changes are possible quickly and easily.

In the production of varnishes and paints, systems with hygienic design also enable the production of water-based products with a **significantly lower use of biocides**. The consistent prevention of zones without or with low flow ensures that no germ nests can form.

Safety instead of risk

When using traditional technologies in process engineering, the risks during powder handling and powder induction in liquids in particular are often underestimated. Health hazards and risks of explosion can be completely ruled out when powders are directly inducted into the liquid dust-free, and processed in a closed system.

Fig. 27: *Health and explosion hazards can be avoided through dust-free suction of powder materials directly into the liquid and processing in a closed system. Image: ExQuisine - stock.adobe.com*

Dust is harmful to health. The admissible limit values for individual powders or liquids are stated in the respective safety data sheets. When filling powders from above into a vessel, this dust always occurs in combination with humidity or solvent vapours released during agitation. Thickening agents, polymers, or even simple dust from food products in combination with humidity form very sticky and difficult-to-clean layers, everywhere. Spectacle wearers know that problem very well. The same layers are created inside the respiratory tract and the lungs. Dust from resins dissolves in solvent vapours and form adhesive resin layers. Silica or clays and vapour form solid coatings – in the pulmonary alveoli. The combination of vapours and dust is often very irritating, sensitising and generally critical.

Ruling out risks of explosion

Most processed powders are organic or organically coated, and thus they are combustible. This causes the risk of a dust explosion. Even if a powder is inert, i.e. it is not combustible itself, but is processed in the presence of inflammable gases and vapours, there is a risk of an explosion, in this case, a gas explosion. The highest risk is the combination of combustible dust with inflammable gases or vapours since the limit values in the safety datasheets of the respective individual components no longer apply and critical figures, such as the lower explosion limit or the minimum ignition energy are significantly reduced.

The crucial measure for fully preventing these health hazards and risks of explosion is **dust-free induction directly into the liquid**, as is possible when using an YSTRAL Conti-TDS.

This way, neither critical dust nor mixtures with humid air or solvent fumes are generated. The powders can even be inducted into the process vessel without opening it. This is particularly interesting for processes in which the penetration of ambient air into the vessel must be prevented by sterile filters.

Fig. 28: *ystral process plant for tablet coating production. Image: ystral*

Inline instead of batch

An increasing number of users are switching from batch production in the process vessel to continuous fabrication without process vessel for large production quantities. In addition to pure liquid processes, powders can also be processed in a continuous process. ystral technologies offer different options for this purpose.

Fig. 29: *In the production of detergents, cleaning agents and personal care products, production processes are realised with slurries or highly concentrated gels. Image: gradt - stock.adobe.com*

For pure liquid processes, inline production can often be very easily realised. It becomes more difficult if powders are to be processed in an inline process, as each powder contains air. In a simple inline process without ventilation, in addition to the powder itself, the air contained in the powder is also inducted and then remains in the product – however, in most cases, this is not wanted. This can be remedied for example with an inline process with ventilation, which is also possible with continuous fabrication (s. Fig. 30). Ventilation takes place via an integrated circuit with a small open vessel.

Uninterrupted production with the YSTRAL Coflow

For products with easy-to-process powders, ystral has developed the YSTRAL Coflow (s. Fig. 31). With the YSTRAL Coflow, solids and liquid components are inducted via solids dispensers or a liquid pump in a controlled way in proportion to quantity, and mixed in a premixing zone. Fine dispersion then occurs via a rotor-stator system, whereby the stator can be designed with different slot widths depending on the application. The product then experiences an increase in pressure via an inducer installed between the premixing zone and the rotor-stator zone. This change in pressure then causes separation of the air that was introduced with the powder, thus a lower residual air content in the product.

Quasi-continuous fabrication

Two process options with technologies from ystral, which do not enable continuous, but quasi-continuous fabrication, are twin tank processes and processes using one working and one buffer tank.

Inline processes with slurries

In the production of detergents, cleaning agents and personal care products, for which a large number of different powders must be processed, production processes with slurries or highly concentrated gels are realised. Using mass flow meters, the individual liquid media are continuously dosed into an inline dispersing machine in optimum order and mixed to produce the end product. This way, different recipes can be produced inline. A batch process is no longer required, recipe changes are easily possible.

Slurries and any other liquids such as liquid thickeners, additives or pigment pastes can be continuously processed by means of pumps and mass flow meters in a single inline machine in the **coating and inks industry** as well.

Fig. 30: *Powder induction in a continuous process without (left) and with (right) ventilation. Images: ystral*

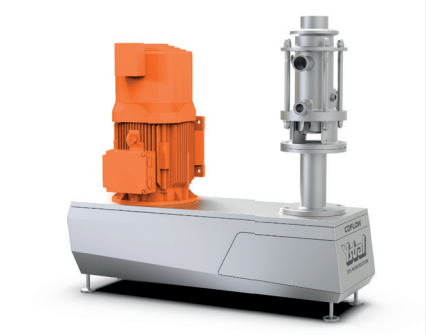

Fig. 31: *The continuously working YSTRAL Coflow powder wetting and dispersing machine. Image: ystral*

Integration of new technologies instead of “Continue as before”

When existing process systems reach their performance limits, do not deliver sufficient quality or no longer meet the current safety requirements, it is not always necessary to replace the entire system. By using new mixing technology directly in the process vessel, or machines that are externally connected via pipes, existing systems can also be upgraded and operated in future with higher efficiency and safety.

Fig. 32: *In a factory used to manufacture plant-based creams and spreads, savings in the millions were achieved through the integration of a single Conti-TDS. Image: Corinna Gissemann – stock.adobe.com*

All ystral machines can be retrofitted into existing plants. If the vessel geometry is appropriate, the existing agitator is simply replaced with a jetstream mixer. However, if this is not possible since the position or flange size is not suitable, the jetstream mixer is supplied with a new welding flange, which could be designed for the top, the side or the bottom of the tank. In this way, the mixer can be fitted in the optimum position and guarantees a completely homogeneous mixing in the shortest time.

Instead of a simple jetstream mixer, multi-purpose machines can be used instead – machines, in which the jetstream mixer can be replaced very easily with a Dispermix, High Shear Dispermix or disperser. Consequently, the user has the option of adjusting the machine easily for future changes to the process. In this way, it is possible to mix, disperse or emulsify as required. Such retrofitted machines can also be supplemented easily as an additional mixer – if the current agitator allows this. The existing agitator is not removed. The welding flange is arranged such that the new mixer and the existing agitator support each other rather than interfere with each other.

Fig. 33: *Inline dispersion machine for integrating into existing process plants. Image: ystral*

Simple integration of external machines

Integrating external machines outside a vessel into existing plants is significantly easier. Just pipes and valves are required. Through integration of an inline dispersion machine in a loop with an existing plant manufacturing flavours and fragrances, the high-pressure homogenisation was not required anymore for 90 % of products made there. This increased the capacity of the entire plant by several factors.

In a modern factory used to manufacture plant-based creams and spreads, savings in the millions were achieved through the integration of a single Conti-TDS. Even if the complete factory was quite new, a more than 60 years old mixing technology was used to add powders and vegetable oil. Since these ingredients cannot simply be added to the large mixing tanks, a small square process vessel with a bottom entry agitator/disperser was installed in a loop with the main tank. Powders and oil were added into the vortex of this tank. The

droplet size distribution of the emulsion achieved was 20 to 30 µm and the process time for a complete procedure was two hours. By integrating a Conti-TDS instead of this mixing system, the process was less than 30 minutes and the droplet size was reduced to below 2 µm, which also meant an enormous reduction in the high-pressure homogenisation, if required at all.

Often, Conti-TDS machines are also integrated subsequently, as the addition of powder into the vessel from the top is no longer permitted

Dust-free processing of powders

Conti-TDS machines are often integrated subsequently because the addition of powders from above into a vessel is no longer permitted. The reasons for this are dust, hygienic problems and the risk of an explosion when adding powders from above. In this case, the Conti-TDS is integrated so that the powders can be added dust-free and safely, not only into the existing plant but directly into the liquid product.

Is there need for improvement with your current mixing processes?

Are you currently planning an extension of your production capacity, an adaptation to changed provisions or the use of new raw materials? Please do not hesitate to contact us to learn how your processes can be optimised with technologies by ystral.

We are certain that there are many undiscovered reserves within your processes, and we can determine and utilise this potential by applying the know-how we have gained in the past five decades. The optimum solution for the respective issue is what drives us.

Our highly efficient mixing, dispersing and powder wetting machines are used whenever powder or liquids are to be mixed into or dispersed in other liquids. A whole series of innovative and at the same tried and tested system and machine types is available for this purpose, which are adapted to the individual requirements of the customers in terms of process technology. They seamlessly and flexibly integrate into the respective production chain.

Individual machines and process systems are the core competence of ystral here. Every system is different, and so is every solution. ystral combines machines and components in such a way that a system which is precisely tailored to your requirements is created. This versatility challenges our experienced development team once more each time – and is our driver at the same time, as your processes are added value!

Your ystral team

110% MIXING SOLUTIONS

What can we do for your process?

We look forward to talking to you – and to challenging mixing requirements.

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