High-Shear Mixing

TPS

The power of simplicity

Design Philosophy

A collaboration between TPS' own staff and external consultants was established to design a truly unique rotor-stator system inclusive of a pump house.

Five primary criteria were identified:

- Low noise emission
- A low $NPSH_r$ to minimise cavitation
- High shear for increased homogenisation effect
- System efficiency to optimise the operational cost
- Manufacturing methods to lower the investment

Mixers to be CE marked and manufactured according to EHEDG guidelines.
Certificate issued following Food Contact Materials standards set out in EN 1935/2004.
TPS is subject to regular checks by The Danish Veterinary and Food Administration.

A philosophy which creates the best industrial-scale high-shear mixer.

What is High-Shear Mixing

High-shear mixing is a process in which one phase or ingredient is dispersed into a main continuous phase with which it would normally be immiscible. This is achieved through a rotor or impeller, and a stationary component called a stator in a tank or pump. High-shear mixing is used in various industries, including dairy, beverage, food, personal care, and pharmaceuticals, for multiple applications such as emulsification, homogenisation, particle size reduction, and dispersion. There are several types of high-shear mixers, including batch high-shear mixers, inline high-shear mixers, inline powder mixers, high-shear granulators, and ultra-high-shear inline mixers. Batch high-shear mixers are used to process a given volume of material quickly and are typically used when faster processing is the main requirement and space is not limited. Inline high-shear mixers, on the other hand, offer a more controlled mixing environment and can be used as part of a continuous process. They are also more compact and take up less space. Inline powder mixers are equipped with a hopper to introduce powder into a liquid stream. They are often used in the production of emulsions and suspensions. High-shear granulators produce fine particles from a wet mass, and ultra-high-shear inline mixers produce very small droplets or achieve a high level of particle size reduction. High-shear mixing is often used to achieve equilibrium mixing, in which all components of the mixture are evenly distributed and in a stable state. This can be achieved by passing the mixture through the high-shear mixer multiple times. High-shear mixing is also used in the production of emulsions, which are mixtures of two or more immiscible liquids, such as oil and water. Emulsions can be created using high-shear mixers by introducing one liquid into the other in the presence of an emulsifying agent, which helps to stabilise the emulsion. High-shear mixers are also used in the production of suspensions, mixtures of fine particles in a fluid, and lyosols, gases dispersed in liquids. In addition to the various applications and types of high-shear mixers, several factors can affect the efficiency and effectiveness of the mixing process. These include the design of the rotor and stator, the rotational speed of the rotor, the distance between the rotor and stator and the time in the mixer. The material being mixed, the properties of the phases being mixed, and the desired final product can also impact the mixing process. Overall, high-shear mixing is a powerful and versatile tool that is used in a wide range of industries for a variety of applications. It allows for the efficient and effective mixing of immiscible phases and the production of stable emulsions, suspensions, lyosols, and granular products.

Welcome to TPS, a company specialising in high-shear mixing solutions for a variety of industries. Our team is led by Erik Dath Harbo and Claus Siegaard, both of whom have over 25 years of experience with dairy, food and beverage technologies and a deep understanding of the process engineering industry.

At TPS, we use the latest Computer Fluid Dynamics technology and our industry experience to design our high-shear mixers, ensuring maximum efficiency and effectiveness. We also have a strong application knowledge, allowing us to tailor our solutions to meet the specific needs of our clients. We have a test station located in Denmark where we can demonstrate the capabilities of our high-shear mixers and work with clients to find the best solution for their needs.

Our rotor-stator system is machined, assembled, and tested in-house to ensure the highest level of quality and performance. We take pride in our attention to detail and commitment to delivering top-notch products to our clients.

Thank you for considering TPS for your high-shear mixing needs. We look forward to working with you and helping you achieve your desired results.

MD, Erik Dath Harbo
CEO, Claus Siegaard

MixSing Shear

The MixSing Shear pump is typically used for homogenisation, emulsification, smoothing, and breakdown of particles. Operating as a standard centrifugal pump with the addition of high-shear mixing capabilities, it is a fit for most operations. The pump house is designed for a max working pressure of 10 bar allowing the pump to be fed from a lobe pump for higher viscous products.

The unique rotor-stator high shear system takes advantage of the low $NPSH_r$ minimising the risk of cavitation. With such low $NPSH_r$, the MixSing Shear pump can be integrated into process systems with a low supply pressure to the pump.

The rotor-stator system is custom-made for each application and pump, thus adapting it to the specific purpose. Keeping manufacturing costs low and still allowing for customisation, the rotor and stator are cast in AISI 316L as blanks and finally machined, assembled, and tested in Denmark.

A secondary design criterion, “uptime security”, was introduced, and it is even more critical to the daily operation - no unique parts nor tools are required! In addition to the cast parts (long-lasting parts), the pump system consists of parts readily available on the open marke: a standard multinorm motor, an elastomer, and a flushed seal.

A tertiary design criterion, “high outlet pressure”, was developed to minimise the cases where a secondary downstream pump is required. It is leading to both operational cost and investment savings. The pump will have an outlet pressure of 2 bar(g) at 2,600 rpm for products that are pumpable by a centrifugal pump.

Maximising efficiencies, the pump is designed as a direct-driven pump system, and the pump house is intended to minimise back-flow and have an evenly distributed laminar flow pattern.

Designed based on the European norms and standards for the food, dairy, and beverage industries, the pump system can be used “globally” with no or minor adjustments.

With a high >200,000 s^{-1} nominal shear rate, the pump provides industry-high homogenising effects in a shear pump.

MixSing Shear is a standalone product and a building block in our MixSing Injector and MixSing Vortex systems.

Operating specification	
Maximum pressure	10 bar
Cleaning	Designed for CIP
Operating data	
Liquid flow rate	>30,000 l/h | Other capacities on request
Service water	100 l/h
Motor	11 kW
Viscosity	<1,000 cps | Pumpable by centrifugal pump
Nominal shear rate	>200,000 s^{-1}

Beverage

“A smoothie is a thick rich, primarily fruit based beverage full of minerals and vitamins and often used as a meal replacement”

Recombined Milk

“Recombined milk, also known as reconstituted milk or reconstituted cream, is a dairy product made by blending milk powder or other milk solids with water. ”

MixSing Standard

Building on the unique rotor-stator unit developed, the MixSing Standard is the first level of tank-based high-shear mixers for low-capacity low-cost recombined products such as milk, ice cream mixes, and pancake mixes.

All the tank-based systems have the rotor-stator unit installed centrally in the tank bottom cone for the optimal and uniform mixing of the tank content. A vortex breaker is installed in the tank to ensure that the product circulation is broken up and turned downwards into the rotor-stator unit. The design allows an outlet valve to be placed close to the rotor-stator unit for optimal emptying of the tank.

Ingredients are filled into the tank via a manway placed on the top cone of the Standard. The filling can be done either manually from a platform or semi/automatically from an ingredient unloading system.

The rotor-stator unit is custom-made for each application and tank, thus adapting it to the specific case.

Keeping manufacturing costs low and still allowing for customisation, the rotor and stator are cast in AISI 316L as blanks and finally machined, assembled, and tested in Denmark.

Committing to the philosophy of no unique parts or tools, tank-based high-shear mixers generally require no unique parts or tools! In addition to the cast parts (long-lasting parts), the tank-based system consists of parts readily available on the open market: a standard multinorm motor, an elastomer, a flushed seal, a manway gasket, site glasses, spray balls, level switches, and a temperature transmitter from globally recognised OEMs.

Maximising efficiencies, the unit is designed as a direct-driven rotor-stator motor system. This results in a more straightforward and service-friendly design, reducing production cost.

Designed based on the European norms and standards for the food, dairy, and beverage industries, the tank system can be used “globally” with few alterations.

With the high >200,000 s^{-1} nominal shear rate, the tank system provides industry-high homogenising effects in a tank-based high-shear mixing system.

Fully CIP’able with two CIP spray balls installed in the ceiling of the tank.

MixSing Standard is a standalone product and building block in our tank-based high-mixing series.

Operating specification	
Maximum pressure	Atmospehric
Cleaning	Designed for CIP
Tank volume	50 to 6,000 l
Powder tipping height	True tank top
Operating data	
Power	11 to 110 kW
Service water	100 l/h
Viscosity	<1,500 cps
Nominal shear rate	>200,000 s^{-1}

MixSing Process

Building on the rotor-stator unit centrally installed in the tank bottom cone, as on the MixSing Vacuum, the MixSing Process comes with additional and essential features. With the integrated scrape agitator, the Process is ideal for complex formulations resulting in products with high viscosity, such as mayonnaise, hummus, and particulate sauces.

The Process introduces the possibility of adjusting the mix temperature by steam, hot or cold water using an indirect energy transfer system on the cylinder and cone of the tank. The design can, upon request, be either a pressure-tested AISI 304 dimple jacket or a half-pipe design. For products requiring fast heating, a separate culinary steam system can be installed for direct steam injection into the tank.

The Process tank is typically insulated with AISI 304 clad mineral wool.

Designed for products with viscosities up to 75,000 cps, the Process is designed with a top-mounted internal scrape agitator. The scrape agitator has been designed taking into consideration three main points [1] minimal deposits on the wall and bottom, [2] no loose parts, and [3] high durability of the blade material. To facilitate this, a new and unique mounting system has been designed. The design keeps the blade in place during operation but allows the blade to move during CIP, allowing for complete CIP.

PEEK plastic was selected as the blade material due to its tough, strong, and rigid form, with superior creep resistance. Further, PEEK is excellent for applications where thermal and chemical properties are essential to the performance.

Each PEEK scraper blade is individually cut and imprinted with the relevant system information.

The Process is often used for higher-value products where high accuracy and uptime are critical or high-capacity automated processes to minimise operator interaction. Often used for multiple hourly batch processes in the prepared food industry.

Continuing the no unique parts nor tools required philosophy, the Process' additional parts are also readily available on the open market. A gear motor and a coupling are the extra parts, except for the PEEK blades and a uniquely designed tool to install the PEEK blades. The tool is free issued with the Process. The PEEK blades are considered consumables.

Operating specification	
Maximum pressure	-1.0 to 0.5 barg | Other pressures available on request
Cleaning	Designed for CIP
Tank volume	50 to 6,000 l
Powder tipping height	Tank wall with vacuum system
Operating data	
Power	11 to 110 kW
Service water	300 l/h @ 20°C
Powder capacity	< 20,000 kg/h | Other capacities available on request
Viscosity	<75,000 cps | Higher viscosities if confirmed by trials
Nominal shear rate	>200,000 s^{-1}

Prepared Food

"Condiments are food additives that enhance the flavour and appearance of dishes. They can be in the form of sauces, spreads, or seasonings and are often added to dishes before serving."

Sugar

“In 2024 the per capita consumption is expected to be 36 kg in developed countries and 25 kg in developing countries”

MixSing Injector

Building on the high-shear capabilities of the MixSing Shear, the MixSing Injector comes with additional and essential features. Typically used for mixing of powders into liquids such as dissloving sugar and recombined products.

The Injector introduces a hopper for the addition of powders. Loading powders into a hopper is a work hazard for the operators. Thus, to improve the ergonomics, the Injector is designed with an adjustable and low tipping height of 86 cm. Further, by leaving the hopper exposed, the design minimises the arm stretching required by the operator to reach the hopper, thus reducing the risk of building back pains.

The hopper comes in a large 73 l standard size, allowing almost two 25 kg bags to be emptied onto the hopper. On request, other volumes can be designed.

The optional table supports the bags being loaded into the hopper by taking the load of the bag and allowing the operator to prepare multiple bags at once. The table is movable, allows flexible integration with the hopper (left or right-side tipping), and fits into the narrowest spaces. The edges of the table are curved upwards to reduce powder spills onto the floor. The adjustable feet enable the table and hopper to align to slide bags to the hopper easily.

Within the hopper, an optional mesh can be installed. The purpose of the mesh is to “capture” larger particles/lumps or a large part of a bag before entering the hopper and causing disruptions of the operation.

Designed with a tiny footprint of 1.3 m^2, the Injector can often fit into the space taken up by older equipment not necessarily designed to meet today’s requirements for human work safety and is, therefore, a fit in both upgrade and new projects.

Continuing the no unique parts nor tools required philosophy, the Injector’s additional parts are also readily available on the open market, with a diaphragm and needle valve being the most exotic new parts.

An operator can continuously unload 50-75 kg powder/minute (2-3 bags of 25 kg); therefore, the Injector has been designed with a capacity of < 100 kg/minute not to slow down the operator.

The powder flows through a valve into a uniquely designed injector module to facilitate the high flow rate.

Operating specification	
Maximum pressure	10 bar
Cleaning	Designed for CIP
Hopper volume	73 l | Other sizes available on request
Powder Injector	Included
Grid opening | Rod diameter	50 x 50 mm | 8 mm
Powder tipping height	860 mm
Operating data	
Liquid flow rate	>30,000 l/h | Other capacity on request
Powder feed rate	<100 kg/min
Service water	100 l/h
Viscosity	<1,000 cps | Pumpable by centrifugal pump
Nominal shear rate	>200,000 s^{-1}

MixSing Vortex

Building on the high-shear capabilities of the MixSing Shear, the MixSing Vortex comes with additional and essential features. Products taking advantage of the Vortex are products where both powders, liquid, and smaller lumps of ingredients are required.

The Vortex introduces a tank for the addition of powders or liquids. Loading ingredients into a tank is a work hazard for the operators. Thus, to improve ergonomics, the Vortex is designed with a minimum and adjustable low tipping height of 94 cm. Further, by leaving the tank exposed, the design minimises the arm stretching required by the operator to reach the tank, thus reducing the risk of building back pains. An optional tabletop is available to support the bags before unloading them into the tank.

The tank comes in a large 83 l standard size for a circulation flow of >30 m^3/h. The ingredients, powders or liquids are introduced through the open manway. The liquid is introduced at a high flow tangentially into the tank, thus creating a powerful vortex. At the top of the tank, a venturi-shaped cone guides the ingredients into the centre of the Vortex, where they are dispersed into the liquid. The tank bottom is designed both to support the creation of a vortex and to ensure the lowest point outlet to the high-shear pump. On request, other volumes can be developed, including a vacuum system.

The optional table supports the bags being loaded into the tank by taking the load of the bag and allowing the operator to prepare multiple bags at once. The table is movable, allows for flexible integration with the tank (left or right-side tipping), and fits into the narrowest spaces. The edges of the table are curved upwards to reduce powder spills onto the floor. The adjustable feet enable the table and tank to align to slide bags to the tank easily.

Designed with a tiny footprint of 1.1 m^2, the Vortex can often fit into the space taken up by older equipment not necessarily designed to meet today's requirements for human work safety and is, therefore, a fit in both upgrade and new projects.

Continuing the no unique parts nor tools required philosophy, the Vortex's additional parts are readily available on the open market, with a level sensor, pressure transmitter, safety switch, and butterfly valves from globally recognised OEMs being the new parts.

An operator can continuously unload 50-75 kg powder/minute (2-3 bags of 25 kg); however, the Vortex can integrate with a big bag emptying system reaching a capacity of < 135 kg/minute.

Fully CIP'able with a CIP spray ball installed on the side of the tank.

Operating specification	
Maximum pressure	Atmospheric
Cleaning	Designed for CIP
Tank volume	83 l | Other sizes available on request
Powder tipping height	940 mm
Operating data	
Liquid flow rate	>30,000 l/h | Other capacity on request
Powder feed rate	<100 kg/min
Service water	100 l/h
Viscosity	<1,000 cps | Pumpable by centrifugal pump
Nominal shear rate	>200,000 s^{-1}

Dairy

"The average person consumes about 12 kg of ice cream per year"

MixSing Vacuum

Building on the rotor-stator unit centrally installed in the tank bottom cone, as on the MixSing Standard, the MixSing Vacuum comes with additional and essential features. The Vacuum is often used with fully automated process plants such as those designed for nutritional products. Nutritional products take advantage of handling powders in a separate room. The vacuum system allows for a higher powder capacity and less included air.

The Vacuum introduces a liquid ring pump, “the vacuum system”. The vacuum system creates a pressure difference of typical 0.5-0.7 bar, allowing the ingredients (powder and liquid) to be conveyed into the mixer below the liquid surface. Introducing ingredients below the liquid surface further facilitates the lowest content of included air among all the mixer systems.

The Vacuum allows you to connect the mixer directly to a variety of ingredients-vessels: a hopper, a big bag, a drum, an IBC, or a powder emptying station by one or more butterfly valves installed in the bottom cone. A small 25 l hopper is installed on the side of the tank for easy accessibility and to allow accurate dosing of essential but small-volume ingredients.

The vacuum system can continuously convey <20,000 kg/h of ingredients into the mixer, which is why the Vacuum is often used in a multi-pass mixing system, allowing a high upscaling to the batch size, saving investment.

The Vacuum is often used for higher-value products where high accuracy and uptime are critical or high-capacity automated processes to minimise operator interaction.

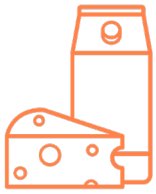
Continuing the no unique parts nor tools required philosophy, the Vacuum’s additional parts are also readily available on the open market. The extra parts include a pressure transmitter, load cells, a liquid ring pump, and butterfly valves.

Operating specification	
Maximum pressure	-1.0 to 0.5 barg | Other pressures available on request
Cleaning	Designed for CIP
Tank volume	50 to 6,000 l
Powder tipping height	Tank wall with vacuum system
Operating data	
Power	11 to 110 kW
Service water	300 l/h @ 20°C
Powder capacity	<20,000 kg/h | Other capacities available on request
Viscosity	<1,500 cps
Nominal shear rate	>200,000 s^{-1}

Infant Formula

"Infant formula is a food specially formulated for infants and young children. It is designed to provide babies with nutrients for growth and development"

MixSing Applications and Many More



Dairy

- Infant formula
- Recombined milk
- Flavoured milk
- Ice cream
- Protein standardisation
- Cappuccino foamer
- Non-diary creamer
- Fat-filled products
- Condensed milk
- Sweetened condensed

Beverage

- Sugar dissolvers
- Syrup preparation
- Stabiliser blends
- Juices & nectars
- Soft drinks
- Smoothies
- Whey based drinks
- Sports & energy drinks
- Sport energy gels

Prepared food

- Sauces (+particulated)
- Mayonnaise
- Mustards
- Ketchup
- Dips
- Salad dressings
- Fruit preparations
- Hummus
- Purees

Personal care

- Gels
- Creams
- Soap
- Shampoo
- Lotions

MixSing Selection Tool

Liquid & powder mixing

- Particulates
  - Yes → Vortex, Standard, Vacuum, Process
  - No
- Viscosity
  - 1000 < x ≤ 75,000 cps → Vortex, Standard, Vacuum, Process
  - x <1000 cps, pumpable by a centrifugal pump
- Powder capacity
  - x> 5,000 kg/h → Standard, Vacuum, Process
  - x ≤ 5,000 kg/h
- Air incorporation
  - Low → Deaerated product → Standard, Vacuum, Process
  - High
- Liquid dosing
  - Yes → Vortex, Standard, Vacuum, Process
  - No
- High shear
  - Yes → Injector
  - No → X

Liquid & liquid mixing

- Particulates
  - Yes → Injector, Vortex, Standard, Vacuum, Process
  - No
- Blending
  - Yes → Static
    - Yes → X
    - No → Emulsification
      - No → X
      - Yes → Shear
  - No → X

Shear
- Smoothies

Injector
- Syrup
- Milk
- Chocolate drink

Vortex
- Syrup
- Ice cream
- Milk
- Chocolate drink

Standard
- Flavoured milk
- Milk
- Beverages
- Syrup
- Starch
- Slurries
- Gravies
- Soups

Vacuum
- Infant formula
- Milk

Process
- Prepared food
- Processed cheese
- Jams
- Fruit
- Confectionery
- Personal care

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Contact
Europe: Erik.Harbo@tps.ltd
World: Claus.Siegaard@tps.ltd