CSI | eBOOK

COMPLETE GUIDE TO
MIXERS & BLENDERS
FOR HYGIENIC APPLICATIONS

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INTRODUCTION

This guide is designed to provide an overview of the wide range of sanitary mixers and blenders used in hygienic processing applications in food & beverage processing, pharmaceutical manufacturing, and related industries. It is intended as a primer to aid process engineers and project managers in determining what particular type of mixer or blender to select for a specific application, focusing on factors such as mixing efficiency, results obtained, maintenance requirements, and reliability.

We will provide a general overview of the various types of sanitary mixers and blenders available on the market, their uses, how they work, and the advantages and disadvantages of each when used with different types of materials.

OVERVIEW OF SANITARY MIXERS AND BLENDERS

Sanitary mixers are machines that blend, mix, homogenize, or emulsify various product ingredients in a processing plant. They are used extensively in hygienic industries, including food & beverage processing, pharmaceutical manufacturing, and the home and personal care industries.

Indeed, for these types of businesses, it may accurately be said that mixing and blending is one of the key value-added steps in the manufacturing process. Unlike mixers found in the home, sanitary mixers are large and complex pieces of machinery. To maintain hygienic standards, the majority of hygienic mixing tasks are performed in closed containers with limited air supplies and under controlled temperatures.

In the hygienic processing industries, mixers prepare a wide variety of products, including toothpaste, food coloring, syrups, beverages such as milk and soft drinks, medical ointments, lotions, creams, vitamins, shampoos, and hair dyes, to name just a few.

In food processing factories, mixers add stabilizing preservatives to make food products transportable and suitable for consumption. Operators may use them to combine different types of solids (as is the case with powder mixers) and liquids of various types (both viscous and non-viscous). Mixers may also be used in specialized applications to mix a liquid into a solid or a gas. Specific types of mixers are designed and engineered to handle each of these varying applications, as will be shown in the subsequent sections of this guide.

As previously discussed, sanitary mixers are critical components in hygienic processing systems. On an industrial scale, efficient mixing and blending may be challenging to achieve, and so a great deal of engineering goes into designing and improving mixing processes. Indeed, the specifics of a hygienic processor's mixing techniques may be considered as proprietary by a given manufacturer and provide a competitive advantage for their products in the marketplace.

Compared to mixers used in home applications, sanitary mixers are constructed from a relatively small number of materials that are deemed acceptable. Due to its hygienic properties, stainless steel is the most commonly used alloy found in sanitary mixers, especially those used in the food & beverage processing and pharmaceutical manufacturing industries. For similar reasons of hygiene, mixers used in the hygienic processing industries must also be easy to clean, and a self-draining design is critical for this purpose.

Sanitary industrial mixers are also more highly versatile and sophisticated pieces of equipment when compared to the standard mixers you use in your home. Many of these mixers may be highly automated and programmed to control the mixing speed, time, and ingredients introduced. Some types of sanitary mixers also provide the operator with the option of slowly adding multiple ingredients simultaneously.

As mentioned in the introduction, there is a wide range of sanitary mixers and blenders available on the market, employing an equally wide range of mixing technologies. To organize this guide, we will consider two broad categories of mixers and blenders: batch mixers (which are in-tank type mixers) and continuous mixers (which are in-line mixers incorporated into a process line). Within each of these categories, there are two different types of mixers to be considered as well. Low-shear mixers are commonly used for maintaining product homogeneity, mixing, dissolving, solids suspension, heat transmission, and fermentation applications. High-shear mixers are used for particle size reduction, dispersion, gas injection, homogenization, and emulsification. We will discuss each of these types of sanitary mixers in the following sections.

SANITARY MIXER CATEGORIES

PRIMARY MIXER CATEGORIES

Batch (or in-tank) mixers are the most common types of mixers used in sanitary processing applications. With batch mixers, the materials are first poured into a hopper, tank, or another vessel. Once mixing is complete, the mixed product is poured or pumped out of the tank; the components are cleaned, and the mixer is then ready for processing another batch.

High-volume batch mixers come in several different varieties. Process engineers should consider their product mixing requirements carefully in determining which variant of batch mixer is best suited for a specific application. For the mixing of fluids in batch mixers, a high-speed mixer works for relatively runny, low-to-medium viscosity products. In contrast, very high viscosity products require planetary-type batch mixers.

Somewhere between the lower viscosity fluids and the higher viscosity pastes and doughs, twin shaft mixers work best. We will discuss each of these specific batch mixer types in later sections.

Continuous Feed (or in-line) mixers are the second category of sanitary mixers. In contrast to batch mixers, continuous feed mixers are integrated into a process line and constantly mix products as they flow through the system. Continuous feed mixers allow for more efficient and effective mixing of products, with careful control over product stress and temperature. Additionally, continuous feed mixers are easier to clean, consume less energy, have a smaller footprint, and are more versatile than batch-type mixers.

MECHANISMS USED IN MIXING

Sanitary industrial mixers may generally be grouped into three different categories:

Motorized (or kinetic) mixers: As the name suggests, motorized mixers work with a motor (usually electric, but occasionally pneumatic). Typically, standard motor speeds are too fast for many mixing applications, so gearboxes reduce the speed and increase torque in these types of mixers. Some mixing applications require the use of multi-shaft mixers in which a combination of mixer types (e.g., a twin shaft mixer) blends the product thoroughly. Motorized mixers may also work in either batch or continuous feed mixing applications.

Static mixers are in-line, continuous feed mixers that mix materials as they are pumped past and flow around strategically placed blades and paddles in the mixer's body. Static mixers have no moving parts and function well in a wide range of hygienic processing applications.

Other mixers. In addition to the motorized and static mixers described above, various other devices and methods work as mixers in sanitary processing applications. For mixing non-viscous fluids and for product agitation purposes, flow devices such as jets and nozzles can work as mixers. In these cases, rising gas bubbles from air injected into the product — or alternatively, turbulent fluids — will cause mixing to occur. A device called an eductor uses a high-velocity stream that is accelerated through a nozzle and can be used to entrain and mix a tank's contents. These jet-type mixers and eductors do not work well to combine or mix highly viscous materials. We will discuss each in further detail in later sections of this guide.

SPECIFIC TYPES OF SANITARY MIXERS

MOTORIZED MIXERS

All motorized mixers commonly consist of several components, including a motor, a gear reducer (if required), a shaft of some type containing seals, and an impeller or rotor for mixing the materials. Beyond that, motorized mixers vary widely, as will be shown in the following paragraphs. Common types of motorized mixers include the following:

Low-shear Mixers

Low-shear mixers are designed to combine highly viscous materials which cannot successfully mix using other types of sanitary mixers. These are low-speed, high torque mixers that rotate a large impeller in a tank or vessel that contains the materials to be mixed. To thoroughly mix ingredients, high viscosity mixers usually require a close clearance impeller design (i.e., an impeller covering 85% to 95% of a tank's diameter, compared to 70% coverage with an impeller used in a turbine mixer). Some types of close clearance impellers even have flexible scrapers, effectively covering 100% of the tank's diameter. Tanks used with low-shear mixers must also have a round cross-section to ensure that the impeller will reach all of the products that need mixed, as they will not naturally flow to the impeller.

Low-shear mixers work to mix products such as pastes, putties, doughs, soaps, and even chewing gum, so this is a logical choice for process engineers looking for the best solution to mix these types of materials. Common varieties of high viscosity mixers include planetary mixers, ideal for mixing and kneading dough, and twin shaft mixers, which use a separate, centrally-mounted stirrer to keep moving viscous materials around in the mixer so that all of the product circulates throughout the working zone.

High-shear Mixers

High-shear mixers use small rotors or impellers — together with stationary components called stators mounted in the mixer's body — to create shear forces in the materials to be mixed. These are high-speed mixers used with low viscosity ingredients — either immiscible liquids or powders in liquids. Process engineers often look to them for applications involving agitating, homogenizing, or emulsifying products used in the food, pharmaceutical, and cosmetic industries.

High-shear mixers may work in either batch processing or continuous processing applications, and may be used in either single-pass or recirculating (batch) modes—when used to mix powders, the majority of these types of mixers are batch-type. In batch processing, the mixed components feed into a tank containing the mixer on a rotating shaft at the tank's bottom. In applications where space is not limited, batch-type high-shear mixers provide the fastest processing by volume. In contrast, in-line continuous processing high-shear mixers contain rotor-stator arrays in a housing with an inlet at one end and an outlet at the other. The mixed components move down through the array in a continuous stream, with the whole device acting essentially as a centrifugal pump. Compared to batch-type high-shear mixers, in-line high-shear mixers offer a more controlled mixing environment and take up less space. Processors may also achieve equilibrium mixing by passing the product through the in-line high-shear mixer more than once.

Ampco SHEAR-max in-line high-shear mixer

Turbine and Hydrofoil Mixers

Also known as agitators, this category of sanitary mixers includes a broad range of both low-shear and high-shear motorized mixers characterized by a robust design, various impeller and seal types, and motors ranging in size from 1 HP to 1000 HP. Turbine mixers are batch-type mixers that are usually mounted vertically on the centerline of a cylindrical tank — when there are baffles in the tank — or offset in tanks without baffles. Hydrofoil agitators are common with low viscosity fluids and Turbine agitators are commonly used for low to medium viscosity fluids. And while all turbine mixers have a motor, shaft, and impeller, the impeller may be used with a gear reducer, directly coupled to the motor drive or in specialized applications (e.g., the Alfa Laval Levimag® turbine mixer), indirectly driven via a magnetic force coupling.

Alfa Laval LeviMag® Turbine Mixer

Alfa Laval AL Series Agitator

Powder Mixers

As the name implies, powder mixers are various motorized sanitary mixers used to combine two flowable dry materials, and in specific applications, to mix a powder into a liquid. Commonly used in the dairy, food, and beverage industries, powder mixers may be either batch-type or continuous feed and use several different technologies to perform the mixing operation. Let's review some of the most common types of powder mixers.

1. ***Hybrid Mixers***

   CSI supplier Ampco Pumps manufactures a hybrid hygienic powder mixer that quickly and precisely blends wet and dry ingredients. The POWDER-max reduces processing time and provides optimal product consistency with no batch size limitations. Designed with cleanability in mind, these mixers are clean-in-place capable. These characteristics make it another option for a wide variety of dairy, food, and beverage powder mixing applications, including dissolving stabilizers such as pectin and xanthan gum and emulsifiers.

Ampco POWDER-Max hybrid powder mixer

SPECIFIC TYPES OF SANITARY MIXERS

2. *Ribbon Mixers*

Ribbon mixers are typically batch or continuous-feed mixers that consist of a motor, a large trough to hold the material, and a ribbon-type agitator that does the mixing. The ribbons, often in a double helix configuration, surround a central bar that extends the trough length. The ribbons are angled and balanced in such a way that they continually move materials within the container.

Ribbon mixers operate very slowly and require a lot of torque to work. Process engineers use this type of mixer to mix and combine a wide range of both wet and dry ingredients, including such items as cake mixes, cereals, cocoa, cosmetics, flavorings, gelatin, instant formula, medications, pet food, salad dressing, and seasonings. Ribbon mixers mix ingredients evenly but gently and do a very thorough job. However, the use of a ribbon mixer is not recommended for mixtures that have a final sticky consistency, as the unique design of the blades makes them challenging to clean.

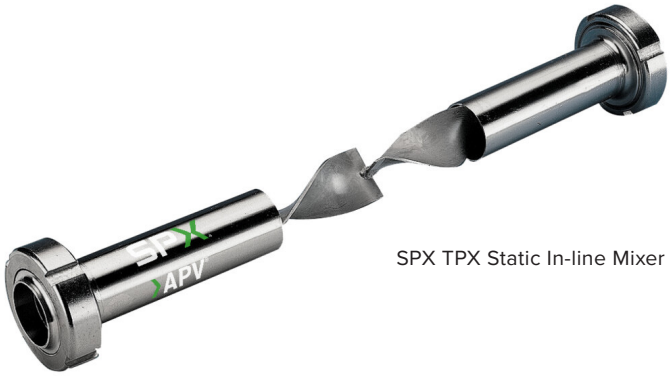
2. *Drum Mixers*

Drum mixers are an older type of powder mixer that can come in batch and continuous feed configurations. As the name suggests, these mixers use a rotating drum mounted on a frame. The materials are introduced into the drum, which rotates continuously until the products are thoroughly mixed, much as in a cement mixer manner. Batching hoppers are variants of drum mixers that incorporate powder storage, the dosing of the various components to be mixed, and the mixing operation itself into the same system. In batch-only mode, drum mixers can mix large quantities of materials all at once, so they may be very efficient for the large-scale mixing of dry ingredients.

STATIC MIXERS

In the category of non-motorized mixers, static mixers are the most common of the sanitary mixers used in processing applications.

Process engineers typically use these continuous-feed mixers to mix miscible liquids, but they may also use them to combine gas streams, or disperse gas into a liquid. The energy required for the mixing process comes from a loss in pressure that occurs as fluids are pumped through the static mixer from a pump located elsewhere in the process line. Static mixers have no moving parts, and so their design resembles that of piping and other pressure vessels. The mixing elements may take many forms, but the most common type is the twisted element. Most features used in static mixers are merely inserted and fixed into a pipe section, although some are designed to be removable for cleaning.



SPX TPX Static In-line Mixer

OTHER TYPES OF MIXERS

Beyond the mixer types described in the preceding sections of this guide, there are other devices incorporated into sanitary processing systems that can perform a mixer's role. For example, processors can use flow devices such as jets and nozzles to perform a mixing function with certain materials. Rising gas bubbles from injected air can also cause

the mixing of some liquids. Two of the most common varieties of these other mixer types described in the subsequent paragraphs.

Rotary Jet Mixers

Rotary jet mixers use a high-powered fluid stream emitting from multiple nozzles on a rotating shaft, operating in much the same manner as a garden sprinkler. Rotary jet mixers mix non-viscous fluids more quickly and efficiently than conventional methods while minimizing energy consumption. They can also handle the dispersions of gases and powders and even be used to clean tanks.

There are many different applications for process engineers and processing plant managers for rotary jet mixers, including sanitary processing applications in the brewery, soft drink production, and biopharmaceutical industries. One of the critical benefits of rotary jet mixers is that operators may use them for various operations usually carried out by separate processing units, such as water de-aeration, syrup/aroma mixing, soft drink carbonization, and clean-in-place applications. This flexibility can save both equipment investment costs and minimize footprints in a processing plant.

Alfa Laval Rotary Jet Mixer

Eductors

Like static mixers, eductors have no moving parts. They operate on the principle of fluid dynamics, using a pressurized liquid accelerated through a nozzle to become a high-velocity stream, mixing and agitating a tank's contents. Eductors can dissolve solids in liquids and mix two or more liquids in a tank without using baffles or moving parts inside the vessel. In product applications, process engineers frequently use eductors to homogenize and emulsify liquids. They may also play a significant role in clean-in-place operations, including tank scrubbing.

Alfa Laval Vortex Radial Eductors

Eductors bring several benefits for mixing and blending fluids. Since they contain no moving parts, maintenance expense with eductors is minimal. And since the eductor can generate a directed flow within the materials to be mixed — including viscous fluids, slurries, and suspensions — eductors can produce a unique agitation that is not available with other types of mixers.

NEXT STEPS

As we've demonstrated in this guide, there are many sanitary mixers and blenders suitable for use in the hygienic processing industries — each employing several different technologies appropriate for various mixing applications. For process engineers and project managers facing this plethora of choices in sanitary mixers, the consideration of which to use boils down to three things:

1. The nature of the materials you're mixing (e.g., viscous versus non-viscous, wet versus dry)
2. The end results expected (e.g., materials blending and mixing, pulverization, agitation)
3. The desired operational efficiencies (e.g., cost of repairs, ease in cleaning, etc.)

CSI is proud to represent several vendors who manufacture sanitary mixing and blending equipment, and we incorporate their products in our processing systems.

Contact CSI today at 417.831.1411 to discuss your specific sanitary mixing and/or blending requirements in greater detail.

NOTES

ABOUT CSI

Central States Industrial Equipment (CSI) is a leader in detail design and execution for hygienic process systems in the food, dairy, beverage, pharmaceutical, biotechnology, home and personal care industries. CSI also distributes a comprehensive range of sanitary processing equipment, including fittings, pumps, valves, tubing, and instrumentation.

Specializing in cleaning systems, process piping, system start-ups, and equipment testing, CSI leverages technology, intellectual property, and industry expertise to deliver solutions to processing problems. Experienced CSI engineers configure or reconfigure sanitary projects large and small, develop new systems from scratch, and optimize existing processes. They collaborate with internal design and fabrication teams to provide innovative solutions for specific customer needs using the latest CAD technology and 3D scanners.

State-of-the-art Clean-in-place (CIP) systems from CSI deliver reliable and repeatable cleaning to ensure product quality and consistency—with the expertise required to ensure proper specification and placement.

Experienced CSI fabricators of custom fittings, transfer and utility panels, valve manifolds, and large skid systems practice mechanical execution to the highest industry standards. Expert project managers use planning practices that ensure solutions meet customer needs and timelines.

CSI stocks complete lines of corrosion-resistant Super Alloys™ AL-6XN® and Hastelloy® C-22®. With four warehouses located across the United States, CSI is the premiere source for hygienic piping, valves, fittings, pumps, heat exchangers, spray devices, and MRO supplies.

For over 40 years, processors, OEM's, mechanical and electrical contractors, and engineering firms and resellers in the processing industry have turned to Central States Industrial Equipment for its breadth of experience, its depth of expertise, and its commitment to innovation.