Matching Batch Style Water-Based Cleaning Advances to Your Cleaning Needs

by Miraclean® Ultrasonics, Ashville, NY

Batch style water-based parts cleaning has come a long way since the Montreal Protocol of 1988 diverted regulated solvent users away from products like Freon™ and 1,1,1 to water-based parts cleaning instead. Time and experience have led to advanced cleaning packages which may combine various mechanical actions and process steps, new generation chemistries, and waste minimization techniques. Choosing the package that is right for you comes down to taking a closer look at your particular cleaning needs and goals with some important factors in mind.

How Many, How Fast, How Clean?

How many types of parts will be cleaned, how many parts per load, how many substrates, how many soils—all of these are critical to making cleaning equipment choices. Many companies take a cellular approach to at least gross cleaning these days, with separate cleaning tanks, or separate cleaning lines, dedicated to particular part families and sets of soils. This specificity makes it possible to use soil and substrate appropriate chemistries, best ultrasonic frequencies, and other part-appropriate fixturing and mechanical actions to get the job done right.

Water-based parts cleaning tanks are sized according to batch volume with a couple of inches allowed on all sides for solution movement. Cleaning tanks are typically equipped with electric heat, and larger tanks often feature a filter and/or chip basket loop to trap particulate and extend bath life. A sparger loop skims floating soils into an overflow weir for separate disposal and prevents soils from re-depositing on clean parts during exit from the tank. In applications where there is heavy oil loading, an oil coalescer or separator can be integrated with the tank operation, again to extend bath life and to separate oil for disposal.

Knowledge of substrates and soils—or better yet, knowledge plus test-cleaning of parts—will give you a sense of required equipment, chemistry, temperature, and process time to complete the cleaning successfully. Some cleaning operations can be completed in a single clean tank followed by a rinse. Other operations with heavier soil loading can benefit from having more than one cleaning tank. The heavier soil is removed in the first cleaning tank, and remaining contaminants are removed in the second cleaning station. An additional benefit of having more than one cleaning tank to handle heavy soil loading is that the subsequent cleaning tanks will stay cleaner longer and require less frequent dumping. One customer removing heavy buffing compound from precision parts, for example, dumps their first clean station once a day and their second clean station once a week. Other applications dump less often.

Multiple station systems are available as manual systems or as automated systems with PLC or PC control. Systems can be delivered with the level of trim that is appropriate for your goals. Automated systems come programmed to process parts per your cleaning specifications and may contain password protected screens for on-site program modifications. When required, such systems can be designed to automatically fill, drain, add chemistry, monitor flow rates, register ultrasonic output, track final rinse quality, advance multiple work loads and cleaning recipes simultaneously, and alarm and/or halt process in the event of out of specification conditions. Powered zero accumulating conveyors can stage batches at the load and/or unload end, and systems can discharge into more rigorous clean room environments.

Benefits of Ultrasonics

The role of ultrasonics in a cleaning process is to expedite cleaning and/or to enhance cleaning of complex part geometries. Ultrasonic sound waves are created when a generator transmits energy into a transducer and from there into a wet process tank. Ultrasonic energy introduced into a tank creates microscopic bubbles which subsequently implode, breaking soil free in the process. This is called cavitation and it can occur wherever the solution can go in the tank, including into complex part geometries. This characteristic of ultrasonics can result in noticeably cleaner parts, especially when the chemistry and bath temperature are also matched to the task. Ultrasonic cleaning successes occur on a variety of scales and even include cleaning of parts as large as locomotive shafts and jet engine components prior to repair or rebuild. In many cases cleaning times can be dramatically reduced with the addition

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of ultrasonics to a tank–sometimes from hours to minutes.

Ultrasonics are available in various frequencies. The most versatile and therefore the "universal" frequency is 40 kHz, which can typically be used on a variety of substrates including aluminum and on a wide range of soils. Other frequencies include 25 kHz, a more aggressive frequency suitable for baked on soils on harder substrates such as steel, and 68 kHz and above which are gentler frequencies often used in precision cleaning and/or rinsing applications. The difference in frequencies is the size of the bubbles that they create and the intensity of implosion which therefore occurs. The lower the frequency is, the bigger the bubbles are and the more aggressive the cleaning action.

There are two types of ultrasonic transducers: magnetostrictive and piezoelectric. Magnetostrictive transducers have a ferrous core that is oscillated by an electromagnetic field. They are almost always found in lower frequency applications from 16-20 kHz and are especially suited to heavy loads and high temperatures. Piezoelectric transducers are typically ceramic and are highly efficient. Oscillation of piezoelectric transducers is caused by electrical pulses at the resonate frequency, which is generally between 25 and 170 kHz but may be as high as 250 kHz, with 25-40 kHz being the most common.

The appropriate watt density of ultrasonics in a tank is based on the size of the tank and the mass and weight of the load to be cleaned. When comparing suppliers, it is important to also factor in the type of ultrasonics being offered. Magnetostrictive transducers require roughly 30% more watt density to equal the performance of piezoelectric, so the magnetostrictive tank will have a higher watts number.

When an ultrasonic cleaning tank is going to be used to clean several different types of substrates and/or soils, power control may be desirable. This allows the ultrasonic generators to be dialed down for more delicate parts and up for more impervious substrates. Multiple frequency ultrasonic generators are also available for this purpose, to provide enhanced cleaning when diverse substrates, geometries, and soils are going to be cleaned in one tank, or when soil removal from a particular part-geometry will be improved by the introduction of different frequencies at different times in the cleaning cycle. In multiple-tank applications, different frequencies of ultrasonics may be used in different tanks to attack soils in different ways.

Cleaning success with ultrasonics also depends on other factors including temperature and chemistry. Operating temperatures below 180 degrees F are more conducive to good cavitation, and some cleaning chemistries cavitate better than others. A variety of cleaning chemistries can be used with ultrasonics, from acidic cleaners to high alkaline cleaners as well as semi-aqueous products. Chemistries should be matched to the soil that is being removed and the substrate(s) of the parts. When multiple cleaning tanks are used, multiple chemistries may be also, to attack soils in different ways in each tank, or for more specialized processes such as passivation.

Additional Mechanical Action

Cleaning success can be further enhanced with the introduction of additional mechanical action(s) that may be part specific. This can be especially important in higher throughput operations or in situations where the goal is to let cleaning happen by itself while operators perform other tasks. Additional mechanical actions may include spray under immersion, air spiders, spray on exit, vertical agitation, and/or rotation.

One popular system for heavy duty cleaning combines ultrasonics and vertical agitation to clean a wide range of parts. Available in various sizes and weight capacities, this "parts washer" type of system provides active cleaning of parts while the operator is free to perform other tasks. The operator loads dirty parts onto the agitating platform at countertop level. At the push of a button, the process cycle engages and the load lowers into the wet process tank. The tank is heated and, to extend bath life and improve performance, it is recommended that it be filtered. The timed cleaning cycle features both ultrasonic action and vertical platform agitation which work together to first loosen soil and then dislodge it from the parts. As with other cleaning systems, surface skimming (sparging) and/or oil separating or coalescing can also be integrated with this system to optimize performance and extend bath life. At the completion of the cycle, the platform raises to countertop level again for unloading.

Multiple parts washers in series can be used to provide cleaning and rinsing of parts, and re-circulating hot air dryers equipped with the platform and cycle control are also available. Platforms can be equipped with rollers on these types of systems and rollers can also be provided between process steps. The operator then simply slides or pushes the load across the rollers to the next platform, and engages the cycle for the next step to occur.

Fixturing Makes a Difference

Fixturing of parts so as to expose critical surfaces more directly to the cleaning action can also expedite the cleaning process and improve the performance. Some parts can be cleaned effectively in baskets, especially when spaced apart to allow for solution movement. Basket, rack, and/or carrier design can evolve with part requirements. One job shop uses stainless steel carriers with part-specific inserts in their automated cleaning line. As different types of parts come through the door, they design a new insert to hold them. During the cleaning process, the parts are loaded into the unique fixture which is placed in the universal carrier. The carrier is appropriately sized for the tank work area and designed to integrate with the automated hoist. Thus, any part that can fit within the carrier in any type of insert can potentially be cleaned in the automated cleaning line.

When parts are susceptible to nesting or when part features include blind holes, rotation is often considered. For more durable parts this can mean processing in a motorized barrel which may rotate under solution, in air, or both. More delicate parts may also be rotated using a specially designed covered basket which locks into place in an indexing rotating superstructure. Indexing speed can be so slow as to be almost indiscernible and may take place under solution or in air, or both.

Importance of Good Rinsing

Good rinsing is critical to cleaning success. Lower throughput cleaning operations may rinse in a single tank or sink, with or without a hand-held spray off. As tanks become larger or water consumption becomes a consideration, multiple rinse tanks that counter-flow or cascade can dramatically reduce consumption while providing excellent rinsing through successive dilutions. In this scenario, the cleanest water enters the final rinse and then flows backward to previous rinses before being handled in one of several ways such as (1) going to drain, (2) being re-circulated through a DI or RO water system, (3) becoming make-up water in a cleaning tank, or (4) going to active or passive evaporation. Rinse water may flow continuously while a system is in operation, or fresh water may be introduced only as required based on conductivity or resistivity readings outside the user's level of acceptability. This "rinse quality control" involves a probe being introduced into the desired rinse tank and integrated with an analyzer on the control panel. The user determines the acceptable water quality range and sets the parameters in the analyzer which then calls for fresh water as required.

Ultrasonics may be added to a rinse tank to meet the requirements of precision cleaning applications, in higher production scenarios, or where complex part geometries exist. The advantage of ultrasonics in the rinse tank is once again that cavitation occurs wherever the solution can go, providing beneficial mechanical action during the rinsing process. The addition of ultrasonics into one or more rinse tanks has dramatically reduced rejects due to particles left on parts, so it is frequently recommended in applications where particle count testing is a quality control criterion such as medical, high purity, and aerospace.

When cleaning specifications are rigorous and/or throughput is high, a fresh water spray on exit from the final rinse can also be beneficial. When spot-free rinsing is critical, DI or RO water is the recommended feed. When corrosion is an issue, a water-based corrosion inhibitor may be applied in a dedicated or final rinse. Some cleaning chemistries also have corrosion inhibiting qualities built in which can reduce the risk of in-process corrosion.

Heating the final rinse can expedite the subsequent drying of parts as can an air blow off (manual or automated) on exit from a final rinse in a multiple station line. Batch drying can be accomplished in a single re-circulating hot air dryer, or in multiple dryer stations or tunnel dryers on high throughput lines. In precision cleaning applications, the dryer(s) can be equipped with HEPA filters to meet exacting particle counts.

Parts with heavy oil loading before and after cleaning in an automated ultrasonic parts cleaning line.

The Right Equipment for the Job

The results of test cleaning coupled with information about the particular goals of the project—the stage of cleaning, throughput, budget, and, if applicable, the industry standards—will help to determine equipment recommendations. The methods used to evaluate cleanliness are almost as diverse as the industries that clean, and some facilities use several methods. These may include visual inspection with or without black light or magnification, white glove tests, and water break tests. In many facilities, successful implementation of a subsequent process such as plating, coating, or welding is an important evaluation tool. Clean room applications typically measure particle counts. Many companies use the process of purchasing a new cleaning system as an opportunity to review their cleaning practices and standards and to further refine them. ❐

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