processing liquid, an ultrasonic transducer to introduce the high-frequency sound vibrations into the liquid, and an ultrasonic generator to provide high-frequency electrical energy to power the ultrasonic transducer.

These building blocks may take a variety of forms, depending on the application and the way parts are processed. In its simplest form, the ultrasonic equipment may consist of a self-contained bench-top unit with parts processed manually through the tank. This type of equipment is common in the jewelry industry.

The next step is a multi-tank console-type system with one or more tanks for ultrasonic cleaning, rinsing and drying. Decorative hardware would be a good candidate for cleaning in a multi-tank console system.

Large production systems, with up to several thousand gallons of capacity, most often utilize modular-type immersible ultrasonic transducers mounted in otherwise conventional processing tanks, with the ultrasonic generators located in a separate electrical enclosure for protection against potentially hostile environments. Large, high-volume items (such as automotive wheels and bumpers, sanitary and architectural hardware items, etc.) are cleaned in systems of this size.

Selection of Ultrasonic Equipment

In all cases, it is recommended that the potential ultrasonic equipment supplier be directly involved in the specification of equipment, which should include a process evaluation with actual parts cleaning performed by the supplier and a thorough survey of the installation location, including an on-site visit if possible.

A viable equipment proposal will include details on the ultrasonic equipment and how it is to be used in the application. Important considerations for the ultrasonic system include the number and placement of ultrasonic transducers, their frequency and power rating, protection of the transducers and generators against damage, and detailed warranty information.

Once ultrasonic cleaning equipment is in place, maintaining its effectiveness requires attentiveness to a number of process variables including solution temperature and the elimination of contaminants removed in the cleaning process from the cleaning solution.

System Design

So far, we have discussed the types of contaminants, substrate, chemistry and ultrasonic technology and equipment. All these factors will determine the specifications for the complete cleaning line. The addition of automation is necessary in most precision cleaning applications where process reliability, consistency and high-volume throughput is required.

The parts handling system is one of the most important features of the cleaning line. The ability to optimize the cleaning results, minimize handling and parts damage, and maintain high production throughput is strictly dependent on the parts handling system. Energy-absorbing materials (such as polyethylene or fluoropolymers) should not be used for parts fixturing (baskets, etc). The position of the transducers in the tank will affect the ability to maintain the uniformity of the ultrasonic energy. Bottom-mounted transducers are preferred, except in cases where sludge buildup is anticipated on the bottom of the tank, or the ratio of tank depth to width exceeds 1.5 to 1. In these cases, side-mounted transducers give better performance and ultrasonic field uniformity.

As discussed previously, the choice of ultrasonic power needs to be adequate to cavitate the entire volume of liquid with the workload in place. Care needs to be given when increasing the ultrasonic power because of problems associated with cavitation erosion and “burning” on some substrate materials.

The choice of chemistry and the process variables have also been discussed above. The addition of weir, sparger and filtration increase the life of the bath and improve the overall efficiency of the process. The level of filtration required is dependent on the type of application and the level of cleanliness required. Sufficient rinsing between process steps is necessary to prevent watermarks.

Final rinsing is usually achieved in deionized water in a two- or three-stage cascaded rinse. These rinses usually have fine particle filtration with a continual introduction of fresh, high purity water in the last rinse. Rinses can be controlled automatically.

Basic Principles

It is almost impossible to design one system to fit every cleaning requirement. Some basic principles have to be followed, however, when designing any cleaning line. Each application or coating process encounters similar problems during and after the cleaning cycle. These problems remain consistent with the variables discussed earlier, such as substrate material, the level and nature of the contamination and process chemistry. Once resolved, we are left with the basics of equipment design, automation and parts handling specific to each application.

With a goal or direction in mind and careful consideration to all the variables discussed here, one can successfully integrate the pre-treatment line with the finishing application. Although the initial equipment investment can be higher than a solvent cleaning system, the investment is often quickly recovered with increased productivity, reduced reject rate and lowered chemical costs.

The ability to meet and exceed the cleaning requirements of any coating application is a result of careful consideration to all the variables discussed earlier, along with close cooperation between the equipment supplier, chemical supplier and the customer. **P&SF**

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