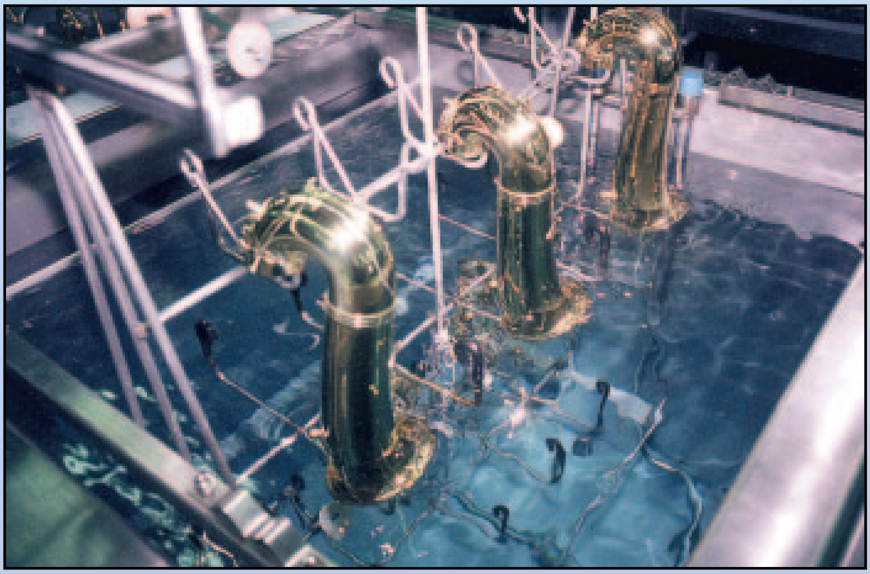
Precision Cleaning Prior to Plating & Coating Applications

By Brian T. Nevill

In his book "The Seven Habits of Highly Effective People," Stephen R. Covey writes: "Begin with the end in mind." To begin with the end in mind means to start with a clear understanding of your direction and final goal. In the finishing industry, the goal is to provide a finish that meets and, when possible, exceeds the criteria given by the customer. The single most important step one can take to achieve this goal is to give careful thought and consideration to the cleaning process prior to the final finishing operation.

The level of contamination and the cleanliness requirements will vary, depending on the finish. Once the required cleanliness level has been determined, the next step is to identify the characteristics and process parameters required to achieve it reliably. This article identifies a number of key factors that contribute to the effectiveness and final success of the cleaning process utilizing aqueous cleaning technology. Aqueous cleaning lines have been proven successful in a number of applications, including electroplating, powder coating and vacuum coating. Each line is specifically designed for that application—taking into consideration the substrate material, production throughput, part configuration and type of contaminants.



An ultrasonic cleaning system removes polishing compounds from these brass musical instrument components prior to lacquer coating. (Photo courtesy of CAE Blackstone.)

Effects of Cleaning On Coating Performance

Depending on the finish being applied, improper cleaning may result in total failure (poor adhesion); surface irregularities, including roughness, pits, voids or porosity; and/or localized adhesion problems in difficult-to-reach areas (such as countersinks or holes). Additional coating failures can occur during corrosion testing, resulting in complete or partial failure of the batch. Other performance characteristics may include hardness, wear resistance and color uniformity. However, these factors tend to involve problems within the post-coating or plating process rather than the cleaning process.

Types of Contaminants

The type of contamination will vary depending on the application, substrate material and manufacturing processes carried out prior to finishing. Contaminants may include machining lubricants, dyes, oil, grease, waxes, buffing compounds, metallic particles and fingerprints. Polishing and buffing compounds are, perhaps, the most difficult contaminants to remove. Their removal becomes even more difficult if they are baked on or if they are allowed to dry out prior to cleaning.

The binders or waxes found in buffing and polishing compounds, if not thoroughly removed, will cause defects and eventually contaminate the entire finishing process.

Other types of contaminants include plating salts, chemical residue, or films left on the substrate prior to coating. This can be a result of poor rinsing or incompatibility of chemistries in the line. Inadequate rinsing, filtration or poor quality rinsewater will result in surface contamination, water spots and subsequent difficulties in the finishing process.

Substrate Material

The composition or chemistry of the base metal is one of the most important factors when choosing a cleaning process. The cleaning chemistry must be compatible with the substrate material or base metal. In addition to the potential for etching or pitting of the base metal by the process chemistry, there is the possibility of erosion caused by improper selection of ultrasonic equipment. In this situation, excessive ultrasonic power or incorrect ultrasonic frequency may cause surface erosion. In many cases, however, pitting or craters visible after finishing are a result of poor electroplating techniques or pre-existing defects in the base material (zinc diecasts).

The alkalinity or pH level is an important factor when working with aluminum, zinc or copper alloys. Variations within the alloys (differing percentages of lead or zinc in copper alloys, for example) will produce different results when evaluating the base metal's ability to withstand attack from alkaline or acidic cleaners. Ferrous materials can flash-rust between cleaning process steps. The process flow, which includes the number of process baths, rinses and dwell time between baths, can be adjusted to minimize this problem, along with the timely addition of rust inhibitors prior to drying.

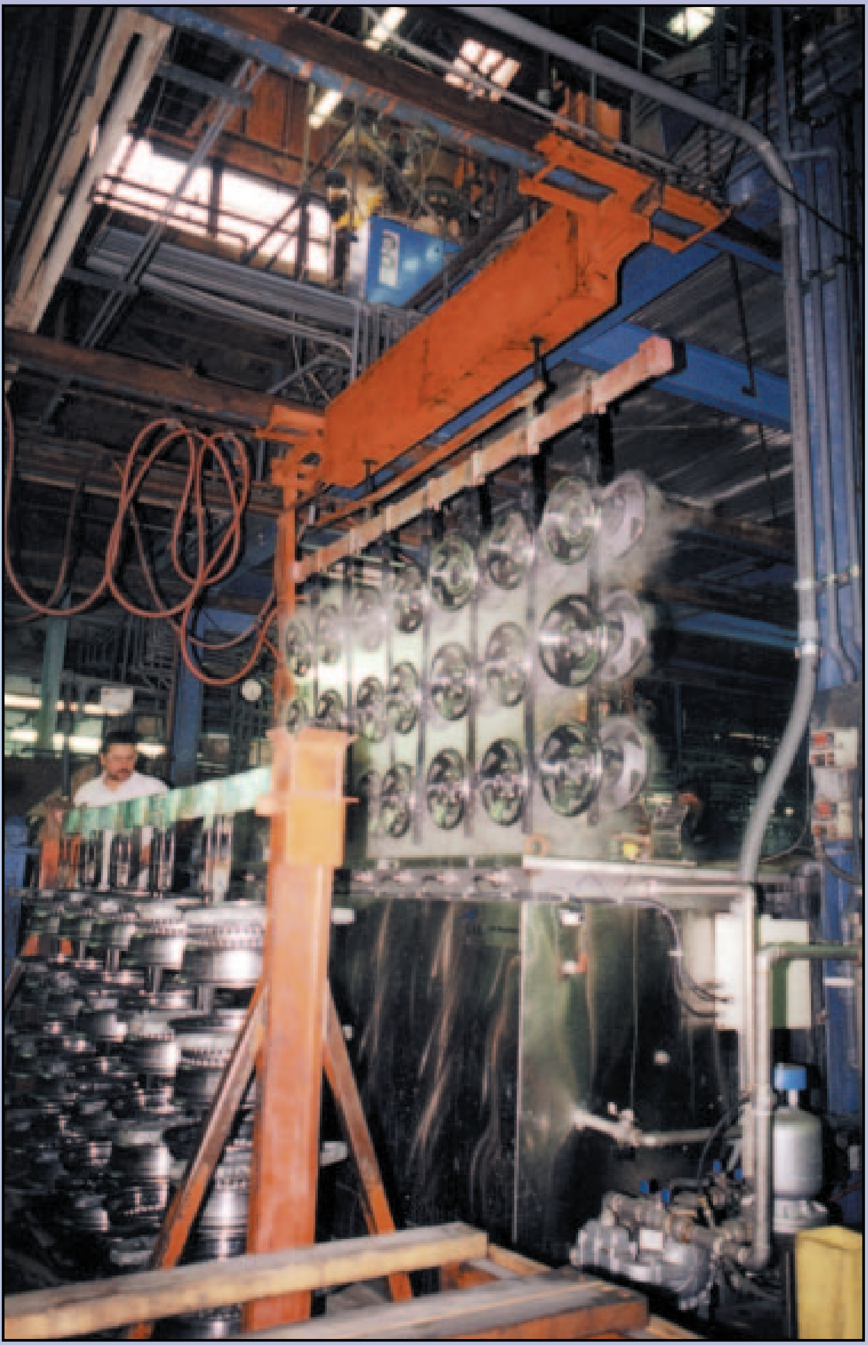
Choice of Chemistry

The correct choice of pre-treatment chemistry is the single most important step in ensuring consistent finish quality and performance. The addition of ultrasonic technology, mechanical agitation and correct filtration go a long way in improving the performance of the chemistry and extending the life of the bath. No equipment enhancement can make the chemistry work, however, if it has not been chosen correctly or is being operated outside the manufacturer's recommendations.

In many instances, problems arise when new equipment is installed without prior process evaluation or when the chemistry that was used for evaluation is changed after installation. The marriage between the chemistry and equipment is critical. To minimize risks and shorten the learning curve, one should choose an equipment manufacturer who works closely with chemical suppliers.

Alkaline chemistries are most commonly used to remove oils, grease, waxes and polishing compounds. Applied by immersion or spray, the alkaline bath is usually followed by a series of rinses. The main processes responsible for the removal of surface contaminants are saponification, mechanical displacement, emulsification and dispersion.

The choice of immersion or spray depends on the application. In the case of buffing and polishing compounds, the most efficient and satisfactory method of cleaning is immersion combined with ultrasonics.



***This 900 gallon ultrasonic cleaning tank is an integral part of a high throughput plating line featured in the September 1998 issue of* Plating and Surface Finishing.**

The main concern with emulsion-type cleaners is the oil-like residue left on the parts after cleaning.

Thorough rinsing and the use of a secondary cleaning with an alkaline detergent will remove this oil-like residue prior to finishing. Ultrasonic technology significantly improves the cleaning efficiency of immersion type systems. Spray cleaning provides the advantages of power impingement and no re-deposition of contaminants.

Electrolytic alkaline cleaning is often a necessary step between the immersion cleaning and plating process. Similar to the mechanical effects of ultrasonic cleaning, electrolytic cleaning provides a high level of agitation close to the work surface—the result of gas evolution at the surface of the part. This method can be particularly effective at removing polishing compounds, fine inert particles or abrasives.

Pre-cleaning in the immersion type cleaner, however, is necessary to reduce the level of contamination and increase the life of the electrolytic cleaning solution.

Acid cleaning is the next process used to remove oxide layers and other contaminants. The cleaner is usually a solution of mineral acid, organic acid or acid salt combined with a wetting agent and detergent. Acid cleaning may not be necessary for painting or powder coating applications. Immersion cleaning is the most common method used when acid cleaning.

Ultrasonic Technology

Today, as a result of advancements in the technology, ultrasonic cleaning has matured into a cost-competitive and highly effective technology that is widely used in a number of plating and coating applications.

Ultrasonic energy is now used extensively in critical cleaning applications to both speed up and enhance the cleaning effect of chemistries. It has also been proven that ultrasonics is the only technique for effective and speedy removal of buffing and polishing compounds from the substrate material. Recognizing the benefits of this technology, chemical manufacturers have developed chemistries specifically for use with ultrasonics.

These chemistries have lower operating temperatures and in some cases are pH-neutral. Just as it is beneficial in cleaning, ultrasonics is also beneficial in the rinsing process. This is because most cleaners are a combination of surfactant and cosurfactant that require thorough rinsing to be effective.

In most applications, ultrasonics in the rinses will help to remove trapped chemicals, plating salts or debris from recesses or blind holes.

This fully enclosed, automated ultrasonic cleaning system was designed especially for processing brass components. (Photo courtesy of CAE Blackstone.)

What is Ultrasonics?

Ultrasonics is the science of sound waves above the frequency normally considered audible for humans (above 18 kilohertz). When vibrations at these high frequencies are introduced into liquids, areas of extremely high vacuum and extremely high pressure are generated alternately at any given point in the liquid as the sound waves pass.

At a point under the influence of vacuum, the liquid is literally torn apart to create what is called a cavitation bubble. As positive pressure replaces the vacuum that formed the cavitation bubble, the bubble collapses in implosion, resulting in high-pressure shock waves that do the work ascribed to ultrasonics. These energetic disturbances generated by the implosions of countless cavitation bubbles enhance processes by providing micro-agitation throughout the liquid volume.

In the cleaning portion of the pretreatment process, the goal is to dissolve or displace a contaminant. Solid contaminants (such as buffing or lapping compound and metal fines) are removed first by dissolving whatever “binder” may be present, and then displacing the contaminants far enough from the substrate to break ionic bonds attracting them to the surface. In all cases, successful contaminant removal requires an exchange of liquid at the contaminant/chemistry interface to replace spent with fresh chemistry to further the contaminant removal process.

Sufficient liquid exchange may be achieved using conventional techniques when the surfaces to be cleaned are smooth and flat. Blind holes, interior surfaces and hidden areas (such as found inside a “hem” in a sheet metal part) offer challenges beyond the capability of many conventional techniques. Ultrasonic cavitation is able to penetrate anyplace where the liquid goes to provide thorough processing in otherwise inaccessible areas.

Ultrasonic Equipment

Ultrasonic cleaning equipment consists of a tank to contain the