Cleaning Techniques for Functional Finishes: From Aluminum to Magnesium & Super-Nickel Alloys

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Aqueous cleaning has replaced solvent-based cleaning operations prior to overhaul cleaning plasma spray and plating operations at United Airlines. An innovative spray-wash technique now has provided more than four years of outstanding service. Substrates prepared for finishing cover a wide range—from aluminum to magnesium to super-nickel alloys. This article covers nozzles and other parts of spray-wash equipment, as well as the types of equipment and size requirements that help UAL meet the desired cleanliness for pre-cleaning, plasma spray and plating operations.

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This photo illustrates the wide variety of parts that an airline overhaul facility handles. These parts will be cleaned in the large parts washer (blue cabinet in background).

Like all other major carriers since the Montreal Protocol of 1987, United Airlines (UAL) was forced to evaluate vapor degreasing operations and seek suitable alternatives. The company's main concern was to find equipment that would accommodate all the part types that were formerly cleaned in the vapor degreaser. It was evident that no one piece of equipment would be able to accomplish what vapor degreasing could do. It was also apparent that no one chemical formulation could replace 1,1,1,-trichloroethane (TCA) for all the different parts and materials.

In UAL's overhaul and repair center in San Francisco, CA, parts are handled that range in size from 12 to 88-in. in diameter and from two to 72-in. in length. Water temperatures in the wash cycle must be maintained at 120˚ to 180˚ F.

In the first phase of going to aqueous cleaning, two parts washers were selected and then outfitted with custom-designed features. An 88-in. x 72-in. work envelope was designed that included an oscillating center lance. Parts weighing up to 2,000 lb can be processed on the turntable. A three-cycle cleaning process is controlled by a programmable logic controller (PLC). A wash tank with a

A jet engine mid-frame case is loaded into the large parts washer.

This close-up of a large jet engine mid-frame case shows the washer's center nozzle lance.This nozzle permits the cleaning of interior surfaces of cylindrically shaped components.

Component parts are loaded into the smaller parts washer.

capacity of 1,250 gal and a rinse tank with a capacity of 950 gal have overflow controls and automatic water make-up.

Stainless Steel Construction

For durability, the entire parts washer is constructed of stainless steel, as is all support equipment. The specification of stainless steel should increase the washer's expected life from 15 to 25 or more years. Mild steel washers are subject to corrosion. Because deionized water and some cleaning formulations accelerate corrosion of mild steel, use of stainless offers greater serviceability of equipment and more flexibility in the choice of cost-effective cleaning agents. All support equipment is also stainless steel. Special 304 stainless steel baskets and fixtures were custom-designed. These hold the workpieces in proper relationship to the spray nozzles. A rotation plan for the baskets/fixtures allows thorough draining of all entrained solutions, thereby extending the life of this auxiliary equipment. A special lifting device facilitates parts loading and handling.

Support Washers in Line Stations

Seventeen aqueous parts washers were designed specifically for wheel overhaul and repair in line stations, accommodating narrow-body and wide-body fleet wheels (737s to 777s; A319s to A320s).

In the accessory component area and electrical shop, a parts washer was installed that includes microfiltration, bag filtration and the capability for extended wash/rinse cycles.

In some of these 17 units, oscillating center nozzle lances and adjustable lances were built in for added flexibility. Parts baskets are loaded around the outside diameter of the turntable, using the center lance to clean the inside circle of parts. The inside diameter of compressor cases and exhaust cases are cleaned in this manner as well.

Spray Nozzles

The parts washer is supported by three types of spray nozzles:

- The wash cycle uses 32 nozzles that are 3/8 x 4-in., generating 50 gpm.
- The rinse system uses 12 nozzles that are 3/8 x 7.0-in. at 50 gpm.
- The fresh and DI water rinses use seven nozzles that are 0.75 gpm at 1000 psi.

It is critical that nozzles be positioned to obtain the best spray pattern possible for maximum cleaning—no matter where the parts are located on the turntable. The nozzle slots must be aligned with the turntable center without a cross-over of the spray pattern. A flushing port manifold is included to provide a plug and flush connection for internal passages. This prevents entrapment of debris.

Engine Overhaul Parts Washer

An oscillating and retractable center-nozzle lance, supported from the roof to provide lateral spray outward and across the turntable, was added to the engine overhaul parts washer. This center nozzle permits the cleaning of interior surfaces of cylindrically shaped components. This is especially useful when washing engine hardware of smaller part sizes that are contained in baskets placed around the outside diameter of the turntable. The center nozzle lance is also able to clean the back side of large or tall parts positioned around the outside of the turntable. These parts shade other parts from direct impingement from the side and bottom spray nozzles.

Parts removed from the components parts washer are loaded into the vacuum dryer.

Aqueous Cleaning Solutions

For best results, the aqueous cleaning chemicals are used that meet the standards set by ARP 1775B and are approved for engine and aircraft parts. These are low-temperature, low-foaming cleaners. The following parameters must be maintained:

- Temperature as specified to ensure cleanliness of parts;
- Adherence to chemical manufacturers' process sheets;
- Chemical concentration (water in wash tanks changed monthly);
- Cleanliness of rinse tanks (water in rinse tanks changed weekly);
- Chemical analyses performed weekly for pH and concentration (the shop is required to make any addition or correction within 24 hr of completion of the chemist's written report).

DI Water

DI water improves the surface finish of cleaned parts for plasma spray, plating and diffused coatings. The DI-treated surface is considered surgically clean and free from contamination. No further cleaning is necessary.

Parts Drying Procedures

After cleaning, all parts must be completely dry before any finishing applications are begun. Vacuum drying ovens are used for complex parts, such as fuel control and electrical components. Convection drying ovens are used in the plasma spray and general overhaul cleaning areas. The ovens can accommodate all sizes of parts—from small parts to those of up to seven ft in diameter (such as a 777 exhaust case).

Vacuum Drying

Parts coming out of the component parts washer are routed to the vacuum dryer, which is located next to the washer. The dryer is a top loading, vertical-cylinder-type of mild steel

Typical Washing Cycle

Two recirculating stages with two intermediate rinses and a final DI water rinse.

First stage:

- Hot detergent spray wash (120˚ to 180˚ F) at high flow rate of 400 gpm, continuously recirculated at 140 psi
- Intermediate fresh water rinse, ambient temp at low flow rate of three gpm circulated at 800 psi to minimize contamination

Second stage:

- Continuously pumped hot water rinse (120˚ to 180˚ F), high flow rate of 175 gpm, recirculated at 65 psi
- Second ambient temp, high pressure rinse at 800 psi, with a low flow rate of three gpm
- Final DI rinse
- Water consumption
- Water lost to the drain is approximately six to nine gal per load cycle, due to use of high and low water flow rates
- Some parts require fewer rinse cycles
- Some loads can be processed using fewer or no intermediate rinse cycles, bringing water consumption down even further

construction with a hydraulically operated clamshell lid. The components are transferred from washer to dryer immediately after cleaning in their basket/fixture for maximum efficiency. The system achieves a maximum vacuum of 0.5 - 5 TORR. Typical dry cycle times range between 20 to 40 min.

Walk-in Drying Oven

A walk-in drying oven is used for the engine parts washer. Immediate transfer from washer to the oven is a must for final water removal. The oven's work zone is 60-in. wide by 96-in. long by 72-in. height. To accomplish faster drying times, it uses a combination air flow pattern with recirculating blowers. Double doors provide easy access and loading. Dry cycle times vary between 15 to 30 min.

Added Benefits of Aqueous Cleaning

Vapor degreasing only removed oil and grease, not dirt, oxidation and corrosion. Aluminum cleaning has improved and UAL now meets surface resistance of 100 micro ohms or less for cleanliness, prior to welding. Also, with vapor degreasing, further cleaning processes often had to be used to prepare the surface of parts for coating applications. This added cost in materials and cycle times.

With aqueous cleaning, there is no hazardous waste to dispose. The water from the wash and rinse tanks at UAL is directed into an industrial drain line and treated in the company's water treatment plant on site.

One Size Does Not Fit All

Flexibility in cleaning operations is a must because no single piece of equipment can adequately handle all sizes or configurations of parts. Neither can one proprietary solution do the job for all cleaning requirements. Continuous process improvement—so important in today's manufacturing arena—must be the philosophy in cleaning, too. One must always search for improved, cost-effective methods for getting the cleaning job done—no matter how big or small the parts. P&SF

About the Author

Douglas B. Wyatt, Jr. is staff representative, engineering, at United Airlines—SFOEP, San Francisco International Airport, San Francisco, CA 94128-3800. He has specialized in cleaning techniques and coatings at UAL for more than 30 years. Doug was instrumental in establishing an innovative cleaning line there, which was featured in the September 1995 issue of P&SF. *For the past five years (and currently), Doug has been the program organizer of AESF's annual Aerospace/Airline Plating and Metal Finishing Forum. At SUR/FIN® 2000, he was presented with the Order of Past Presidents Award in recognition of his leadership of this event. Doug has served two terms as chairman of AESF's Aerospace Applications Finishing Committee. He also represents the commercial airline industry as a "stakeholder" member of the U.S. EPA's Environmental Technology Verification (ETV) Pollution Prevention, Metal Finishing (MF) Technologies Program.*