Educational Guide to Vacuum Coating Processing

Surface Preparation:

Rinsing and Drying

Rinsing and drying are important aspects of substrate cleaning. Rinsing involves dilution and flushing away of material from previous steps. One purpose of rinsing is to prevent the carryover of fluids from one step of a fluid cleaning process to another step. For instance, alkaline cleaning is used to remove oils from steel, and that step should be followed by an acid rinse to remove possible precipitates from the alkaline cleaning. The alkaline bath and the acid bath should be separated by a water rinse (intermediate rinse) to prevent excessive neutralization of the acid bath by carryover.

Another step is the final rinse, which is used to reduce the amount of residual cleaning material so as to reduce solid contamination to an acceptable level after the drying process. When the surface is dried, these solids will tend to concentrate into localized areas on the surface (water spots). These solid residues can be from ionic materials, particulates, precipitates, organic materials, or even living creatures (“wee beasties”).

The amount of acceptable solids that are left on the surface after drying may depend on what subsequent cleaning can be done in the deposition system (in situ cleaning). For example, extensive sputter cleaning in the deposition system, such as used with tool coating, can remove some layered contaminants but is ineffective in removing particulate contamination. However, in some cases—such as semiconductor-device processing—the amount of in situ sputter cleaning that can be used is limited due to bombardment damage, and the degree of final rinsing is critical.

Material may be added to the cleaned surface deliberately during the final rinse. For example, if dry, cleaned tool steel is exposed to air, a “flash rust” will form that will prevent good adhesion of a deposited coating. To impede this flash rust, a flash-rust inhibitor is added to the final rinse. This provides a protective coating on the cleaned surface until it is sputter cleaned in the deposition system. In another example, acetic acid (vinegar) can be added to the final rinse to remove “chrome stain” from electroplated chromium used as a basecoat for decorative/functional coatings. This stain may appear during the cleaning process.

The final rinse may use a fluid that has a low surface tension to increase wetting and spreading over the surface and to penetrate into “hideouts” such as pores and cracks. For example, a water-alcohol mixture (1:1 is typical) has about one-third the surface tension of pure water.

Water is the most common fluid used for rinsing, but other fluids can be used also. The water used for rinsing is treated to remove impurities that can leave residues. The most common treatment is reverse osmosis (RO), which removes most of the impurities and gives “pure” water. If “ultra-pure” water is required, the RO is followed by ion exchange columns, which further remove ionic materials that can cause residues and precipitates[1]. After ionic purification, the water should be further purified by charcoal filters that remove organics and mechanical filters that remove particulates and wee beasties.

When using water for rinsing, the system may be arranged so that the water is used in a cascade manner such that the part is first rinsed in the least pure water followed by rinsing in increasingly pure water. Figure 1 shows a “cascade rinse” system used to give a very high level of cleanliness to the final rinse. In this case, the final-final rinse is in ultra-pure water.

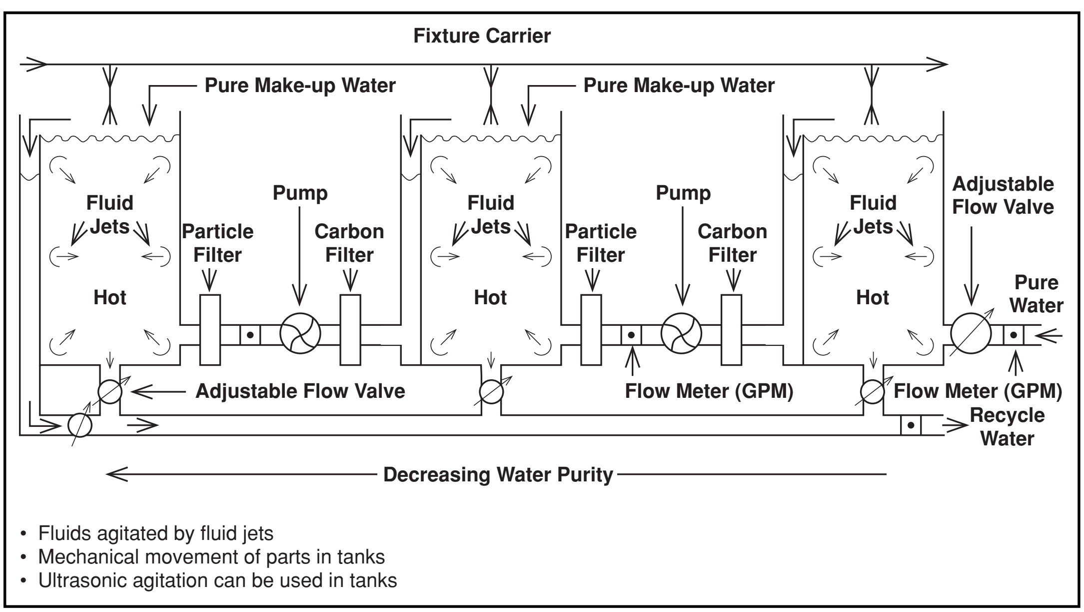

Figure 1: A cascade rinse system gives a very high level of cleanliness to the final rinse.

[1]**Footnote:** The term “deionized (DI) water” is often used to denote pure water, but DI water can still have a high concentration of non-ionic impurities that can leave residues.

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An important aspect in rinsing is proper handling of the water. If care is not taken with the water after purification, it may be recontaminated before use. This contamination may come from the leaching of material from the plumbing or the growth of wee beasties in the distribution system. There may be some further purification, such as filtration, at the "point of use."

Proper rinsing involves disrupting stagnant fluid layers near the surface. The disruption of this layer can be enhanced by the use of mechanical agitation, bubble agitation, fluid jets, spraying, periodic draining, or ultrasonic agitation.

A fundamental axiom of fluid cleaning is that "the surface must be kept wet until the final rinse is performed." If solids are allowed to dry on the surface, they will be much harder to remove in subsequent cleaning steps. In some cases, they may corrode the surface as they concentrate on it.

Unintentional drying can be prevented by controlling the humidity and the time in the transport environment between cleaning stages. Control of the transport time and environment is one advantage of an automated cleaning line, where a transport plenum can be used to monitor and control the air-flow rate and the humidity and temperature of the transport volume above the cleaning tanks. In some cases, parts may be stored under fluids between cleaning stages to keep them wet.

Drying usually involves removing the rinsing fluid both as a liquid and by vaporization. Fluids can be removed by draining, blowing off with air jets, "slinging" off (via centrifugal force), displacing, or dissolving them with a drying agent. Drying agents displace or dissolve the water and replace it with a fluid that is more easily vaporized. An example of a drying agent is anhydrous alcohol, which takes the water into solution. The alcohol has a higher vapor pressure than does water.

When blowing water from a surface, the droplets tend to cling to the trailing edge, then spread back over the surface. The size of these droplets can be reduced by using a water/alcohol mixture.

Fluids are vaporized by heating. Having the piece being cleaned hot as it leaves the rinse bath aids vaporization of the rinse fluid. Having a low humidity in the drying environment aids in vaporization. Keeping the part warm until it is placed in the deposition chamber will decrease readsorption of moisture. This is particularly important for materials that absorb moisture, such as many plastics.

Storage of cleaned parts should prevent recontamination. A typical good storage environment should be warm and dry with particulate and organic-free (filtered) air. When cleaning and storing parts that may have adsorbed water, warm storage can allow desorption of water from the bulk of the material. In some cases, the cleaning line can be integrated into the deposition line such that there is no storage involved in the processing.

Rinsing and drying are an important part of the cleaning process. Care should be taken that these stages of the process be properly designed, controlled, and maintained.

References:

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