

How to Realize Significant Cost Savings with Filtration and Purification

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ABSTRACT

Over the last 2 to 3 years the use of filtration on anodizing acids and associated solutions has increased significantly. There are now many thousands of process tanks operating with continuous filtration on a wide variety of anodizing applications – the number increases each week. New technology has enhanced the efficiency of anodizing processes, reduced disposal and waste treatment costs and significantly improved process control, while improving quality and lowering operating expenses.

An overview of continuous filtration systems, enhanced by airless agitation, including details on sizing appropriate systems and a review of various case histories, together with a comparison between filtered and unfiltered solutions will make the case for continuous filtration systems to eventually become the most widely used method of reducing operating expenses and improving process control in the anodizing industry.

A review of published literature on anodizing processes does not typically touch on the subject of filtration recommendations. For the most part, the chemicals used are non-proprietary commodity items (except in dyeing and cleaning). Sulfuric acid anodizing solution, nickel acetate seal, nitric acid deoxidizer and caustic etch were considered expendable at one time. The wastes in past eras were carefully mixed to neutralize acidity / alkalinity, metals were precipitated and removed and the effluent dumped. Current regulations demand more complex treatment and much lower discharge concentrations.

Water usage at facilities is monitored and mandated to be reduced. Regulatory pressure demands less loading on waste treatment. At the same time, these relatively inexpensive raw materials are becoming a more significant portion of operating cost. If we can effectively double or triple solution life, the savings over time can be tremendous!

The contamination introduced to the anodizing tank does not normally fall from the sky in sufficient quantities to be the major source of trouble in the process. Therefore, we must take into consideration any and all ways in which solids or other impurities such as oily substances could get into the process tanks, and eliminate them at the source. Feed waters used for solution makeup in the process normally contain organic and inorganic contamination, as well as residual chlorine. These contaminants will prematurely deplete the ion exchange resins, which produce the deionized feed water for solution makeup. Therefore, filtration and carbon purification are required to preserve resin bed integrity.

Since quality anodizing begins with good cleaning, we should start our scrutiny with the cleaner and its rinses. Vigorous agitation of the cleaner accelerates soil and oil removal due to the impingement action of the solution on the parts. If we add filtration through a coarse media to maximize solids holding capacity, we will extend the

cleaner's service life. If excess oil floats to the surface, it can be conveniently removed during downtime by decanting or skimming the surface. Additional oil may be removed utilizing a coalescing media to remove non-emulsified oil (Figure 1). A prefilter may also be required to keep the coalescing element free from solids contamination

A method of agitating the anodizing solution with a combination of high flow centrifugal pumps, which draw solution from the tank and return it through a sparger system similar to that used for air agitation, is now being used. However, rather than just perforating the pipe, we strategically place eductors along the horizontal pipe to direct solution across the bottom of a tank or up in a cylindrical zone and into the recesses of the parts to replenish electrolyte (*See Figures 2 & 3*).

Experience has shown almost universal success of this method of agitation in anodizing applications;

Consider the significant advantages that eductor agitation offers:

- Elimination of vapors being introduced into the various process solutions.
- Elimination of uncontrolled temperature changes.
- Prevention of air bubbles from entering the suction lines of centrifugal pumps, which could cause them to cavitate and lose prime.
- Minimizing of dye or seal solution breakdown due to oxidation.

CHOOSING THE RIGHT FILTER

The main criterion for filter design is sufficient solids holding capacity to maintain low-pressure drop across the media for extended periods of time. This is one factor in favor of depth type cartridges, because the pressure drop is usually low over 85% of their life, whereas surface media follows a straight line increase in pressure drop (Figure 4).

PRETREATMENT TANKS

Cleaner tanks using 30-75 micron or coarser filter cartridges, and 3-4 10" cartridges per one hundred gallons (15 sq.ft. of surface area / 100 gallons) and at least 2 turnovers per hour are recommended. The tanks may also require an auxiliary pump and filter, and an oil separator to remove free oil, etc. with a sparger overflow system or skimmer. This auxiliary equipment is for continuous use below 160° F, or during spray system downtime.

Bright dip and etchants may be periodically filtered as required to remove precipitates or contaminants that will streak or spot the work, or to prolong the tank life. We recommend 15-micron filtration with carbon as required. Desmut and pickle tanks should also be filtered to remove soils and oils, etc. that may be dragged into the tank or introduced because of air agitation. Use of an eductor system will reduce heat loss, fumes and misting from the tank surface.

ANODIZING SOLUTIONS

Because of the corrosive atmosphere above anodizing tanks, out-of tank, non-metallic pump and filtration systems are recommended.

Sulfuric acid anodizing solutions

A separate pump and eductor system may be incorporated to reduce fumes, provide proper agitation, minimize the introduction of contaminants and optimize temperature control. Filtration will improve the appearance of the work and extend bath life. Cleaner heat transfer surfaces, with associated lower cooling costs, will result from filtration and improved bath circulation.

Phosphoric acid anodizing, which is also used in composite manufacturing, has important environmental advantages. However, microbial contamination as well as other soils must be removed to assure good adhesion.

Chromates and dye tanks can be filtered as required with 5-15 micron media. Continuous filtration may be required, depending on conditions, to remove precipitates and contaminants that will streak or spot the work, or to prolong the tank life. Oil in the tank will cause spotty or streaked work.

Dyes are often filtered to remove small particles and reaction products formed from interactions between the dye and solution dragged into the dye tank. Uniform color depends on dye solution integrity.

SEALS

Seal tanks should be continuously filtered and carbon treated when organic dyes are present. Precipitates that form in the seal tank, as well as reaction products with the dye, will form a smut on the parts, which must later be removed. Seal tanks should be continuously filtered with 15-micron media, 2-3 turns per hour with 2-4 cartridges per 100 gallons, depending on loading. If organic dyes are present, continuous carbon treatment is recommended to keep the solution from discoloration.

CASE HISTORY #1

A large anodizing plant may have monthly energy consumption at 1,900,000 KWH at a cost of \$152,000/mo or .08¢/KWH. Average production in the anodize department is 2,262 sq. ft/ hr.

It is current density, not voltage that causes the oxide layer to form on an aluminum substrate. As the aluminum concentration and other dissolved contaminants build up in the anodizing bath, current is wasted on the dissolved ions in solution. The voltage has to be increased to compensate for the wasted ionic current to maintain the correct current density, in order to produce the proper thickness.

One hundred square feet of aluminum surface area at a current density of 15 amps per square foot will require rectification of 1,500 amps. The "typical" voltage requirement for aluminum anodizing is in the range of 12-17 volts (depending on the alloy). The power consumption for this application equals the voltage multiplied by the amperage, 15 volts x 1,500 amps = 22,500 watts, or 22.5 KW. For an eight hour day of operation, the power consumed at this rate is 22.5

KW x 8 = 180 KWH. For 1,000 square feet of aluminum anodized per hour, this would equal 1,800 KWH per eight-hour day.

By controlling the dissolved aluminum in the anodize bath, with PRO-pHx chemistry and a properly sized cartridge filtration system, less current is wasted. Thus allowing lower voltage to be used in order to achieve the same anodic thickness. Typically this voltage reduction is in the order of 1-3 volts. Assuming an average of 2 volts less, and plugging this into the power consumption equation from above: 13 volts x 1,500 amps = 19,500 watts, or 19.5 KW for 100 square feet of production per hour, or 156 KWH. For 1,000 square feet of production per hour this equals 1,560 KWH. This is a difference of 240 KWH per eight-hour day.

Using the above plant data, the following calculation applies:

$$\frac{240 \text{ KWH}}{1,000 \text{ sq.ft./hr/shift}} \times \frac{2,262 \text{ sq.ft./hr.}}{\text{day}} \times \frac{3 \text{ shifts}}{\text{day}} \times \frac{300 \text{ days}}{\text{year}} \times \frac{.08\text{¢}}{\text{KWH}} = \$39,088/\text{yr}$$

The literature states the relationship between cooling costs and energy costs at a 4:1 ratio. For this plant, this would calculate to \$156,352 for cooling costs for a total potential energy savings of \$195,440/yr.

Chemical savings in the elimination of acid decants and subsequent caustic soda neutralization costs have been calculated at \$31,800/yr. Therefore, the total chemical and electrical cost savings would be \$227,240/yr.

CASE HISTORY #2
A CHICAGO AREA CONTRACT ANODIZER

	<u>Test Tank # 1</u>	<u>Test Tank # 3</u>	<u>Control Tank # 2</u>
Solution Type	Type II Anodizing	Type II Anodizing	Type II Anodizing
# of Gallons	800 gallons	1200 gallons	1200 gallons
Acid concentration	11-14 % sulfuric acid by weight	11-14 % sulfuric acid by weight	11-14 % sulfuric acid by weight
PRO-pHx and filtration start date	3/4/2004	3/4/2004	
Frequency of decants	previously every 4 months	previously every 4 months	every 4 months
# of gallons/decant	266 to 400 gallons	400 to 600 gallons	400 to 600 gallons
Aluminum content @ start of test	2-2.5 oz/gal	2-2.5 oz/gal	2-2.5 oz/gal
Aluminum the week of	2.5 oz/gal maximum	2.5 oz/gal maximum	** 1.9 oz/gal maximum

8/16/2004

** This untreated bath required decanting two times between 3/4/2004 & 8/16/2004.
Test Tank # 1 & 3 are still operating without decanting as of May 2005.

Filter size @ start up	20 micron string wound cartridges	20 micron string wound cartridges	No filtration
20" cartridge use @ start up	2 every two days	2 every two days	N/A
Micron size after one week	10 micron string wound cartridge	10 micron string wound cartridge	N/A
20" Cartridge use after one week	2 every two days	2 every two days	N/A
Current micron size used	5 micron Polly spun cartridge	5 micron Polly spun cartridge	N/A
20" cartridge use - current	2 each week	2 each week	N/A
Type of filter pump	In-tank cartridge	In-tank cartridge	N/A

Nickel Acetate is used as a sealer.

Many different colors are used in the dyeing process. No adverse effects have been observed since the start date.

Notes:

- Control Tank # 2 was taken out of service permanently when the business moved in early 2005.
- All three tanks were contaminated and near ready for decant on 3/4/2004.
- Reagent chemistry was added to tank # 1 and # 3 at 1% and filtration was started.
- New sulfuric is added two times per week as titrations indicate. The reagent chemistry is replenished @ the rate of 1 % of the added sulfuric volume.
- Previous historical data showed a .2-.3 oz/gal rise in the aluminum content each week.
- 450 gallons of control tank # 2 was decanted and new chemicals were added on 4/4/2004.
- 475 gallons of control tank # 2 was decanted and new chemicals were added on 8/16/2004.

PREVIOUSLY THE TYPE II BATHS WERE NOT OPERATED ABOVE 1.9 OZ/GALLON.

- Currently treated and filtered tanks will anodize properly up to 2.3 oz/gal total aluminum due to the removal of organics and dissolved metals, i.e., aluminum, copper, iron, lead, magnesium, manganese, phosphate and zinc.
- Proprietary additives are used in all baths so that anodizing can be performed at higher temperatures.

- Sodium Hydroxide is no longer purchased for pH adjustment in waste treating the decants.
- Less Sulfuric acid is used to keep the anodizing tanks operating properly.
- Flocculants are no longer purchased for waste treating the decants.
- There are obvious savings realized in reduced manpower & equipment requirements: There are no decanting of baths so the filter press usage and operating manpower are reduced. Less labor is used since the chemical adds are much smaller than were previously required.
- The volume, storing and shipping of the generated non-hazardous waste is reduced.
- Some additional advantages of filtering out the impurities have been, the consistency of acid quality, no down time, no surface oil to drag thru and the obvious environmental benefits.

CONCLUSION

Today's global market environment, with its emphasis on quality, low cost and environmental compliance, has forced many changes in manufacturing in the metal finishing industry. Environmental regulations have made the conservation of process chemicals a "must" for manufacturers. Treatment and disposal costs and their associated liabilities have changed the economics of solution replacement compared to the associated costs of filtration and purification to extend solution life.

Elimination of many vapor-degreasing chemicals has resulted in their replacement with aqueous and semi-aqueous cleaning systems. Existing cleaning systems will have to be upgraded to handle the dirt load.

Improved quality and reduction in rejects require tighter control of all processes. Filtration, purification and new techniques for agitation will help reduce cost, environmental problems, rejects, rework and improve profits.

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