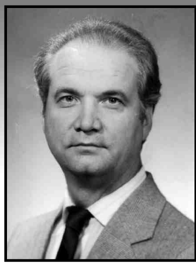

Advice & Counsel

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P2 For Electroless Nickel

Dear Advice & Counsel,

My company has signed on to the Strategic Goals program, and I need a good overview of where I should be looking to optimize our electroless nickel plating operations. Can you provide a "quick guide?" I am especially interested in low-cost options.

Signed,
I. M. Frugal

Dear Ms. Frugal,

There are a number of low-cost opportunities for pollution prevention during the design stage and in the operation of an electroless nickel plating process.

Low-cost pollution prevention options for electroplating processes can be categorized as follows:

- Equipment Design
- Drag-in Reduction
- Water Quality
- Filtration
- Solution Maintenance
- Operational Practices

Let's take a look at these categories:

Equipment Design Impacts On Pollution Prevention

EN Tanks

The choice of material of construction for electroless nickel plating tanks determines the frequency of autocatalytic decomposition (plate-out). This must be balanced by the cost and the tank life. Continued contact with electroless nickel solution will cause most any surface to eventually promote plating. The more passive the material, however, the less plate-out that will occur. Further, the tank material needs to be highly resistant to nitric acid, as this acid is used to dissolve off any plated nickel from tank walls. If the nitric deteriorates the tank walls, more frequent passivation of the tank will be required.

Polypropylene

The most widely used materials for plating tank construction are polypropylene and stainless steel. A 6 to 12 mm (1/4 to 1/2 in.) thick polypropylene liner, installed in a steel or fiberglass support tank, has also been reported to provide successful service and allows for easy replacement of the polypropylene liner.

Polypropylene is relatively inexpensive and is very resistant to plate-out, but it has a finite life of three to five years, so ease of replacement becomes an economic issue, while frequent passivation and catastrophic failure due to deterioration becomes a pollution prevention issue. The life of the welds and of the polypropylene itself are directly related to the strength of nitric acid used in passivating, because the welds (and the polypropylene) are slowly deteriorated by nitric acid. At operating temperatures, polypropylene can be very weak at weld junctions and corners. A heavy part impacting a corner can result in loss of the solution. A cage for overall support plus some form of impact protection from heavy parts is a good idea. Another disadvantage of polypropylene is that it is a combustible material. If exposed to high heat, with no solution in the tank, the tank may melt or catch fire.

Only stress-relieved, unfilled, virgin polypropylene sheets should be used to construct an electroless nickel plating tank. Additives such as fire-retardants or pigments may affect the quality of EN plating. All welds should be spark tested every 6–12 months to verify that the welds are in good condition.

Stainless Steel Tanks

Stainless steel tanks are more expensive and are more prone to plate-out, unless galvanically protected (covered below). They are often used with plastic liners. The advantages and disadvantages of bag liners will be discussed later. Stainless steel tanks can last for many years. Stainless tanks may prove expensive to operate because of periodic plate-out, which necessitates downtime for tank stripping and cleanup. Satisfactory operation has been sustained using well-stabilized electroless nickel solutions along with anodic protection, or liners.

Anodic Protection

This is probably the most dependable passivation method with stainless steel tanks, but these systems require frequent monitoring and control. Application of too high a current may etch tank walls at welds, and contact between wall and plating parts may yield plate-out on the tank walls. If parts contact the tank walls, the EN deposit can be damaged.

Bag Liners

15–30 mil polyvinyl chloride (PVC) or polyethylene (PE) bag liners reduce the need for frequent tank passivation by eliminating the passivation of the tank, as bags are simply rinsed, removed, replaced, and disposed of. These liners are most applicable in operations with small tanks, where utilities such as pumps, filters, etc. don't get in the way of easy bag replacement. When successfully used, these liners can save a significant amount of nitric acid and nickel-bearing waste. Avoid thin (less than 10 mil) bags, because they can easily tear, leak and collect hydrogen gas in pockets (via diffusion through the plastic). Hydrogen explosions have been experienced in some installations using thin bag liners, sending the plating solution out of the tank.

Energy Conservation

Plating tanks should be insulated to minimize their heat loss. Fiberglass or polyurethane insulation is normally applied to the outside walls of the tank. Tanks should employ covers for use during idle periods. It is best to mount the covers to the tank top to avoid loss of the cover into the scrap plastic pile.

Agitation of EN Solutions

A by-product of the electroless nickel plating mechanism is the production of large volumes of hydrogen gas. As the gas leaves the plating surface, the pH of the liquid near that surface tends to increase. A significant increase in pH can precipitate undesirable ions and can affect solution life and deposit quality. Preventing this excessive elevated pH is the solution chemistry (buffers are added to the solution to maintain pH) and agitation of the plating solution. Agitation is accomplished using air agitation or recirculating pump systems (sometimes in combination with the filtration system).

Insufficient levels of agitation have been shown to increase the rate of hypophosphite decomposition, reducing solution life. Excessive agitation may also cause problems in some solutions. A typical air agitation level is between 1.5 to $2 ft^3/ft^2$ of top tank surface area. Recirculating pump systems with or without eductors are normally custom-designed for each application.

Pumps/Piping/Valves

Any failure in the pump, piping or valves on an electroless nickel plating tank can result in solution losses. Pumps in electroless nickel-plating systems are used both for filtration and for solution transfer. CPVC plastic and Type 304 stainless steel are the most commonly used materials for pumps and piping in electroless nickel plating. CPVC pumps are typically used for flow rates less than 80 gpm. Stainless steel is suitable for all flow rates. CPVC plastic is more resistant to plate-out than is stainless steel and is less expensive, but tends to become brittle over time and must be replaced every 3-5 years. All gaskets and o-rings for electroless nickel systems should be resistant to chemical attack by the hot solution (Viton or equivalent).

Polypropylene is a relatively poor choice for piping, as it has much lower strength at the elevated temperatures most EN solutions operate. Avoid gluing plastic piping as much as possible to avoid contamination of the plating solution by organics from the glue. Threaded plastic joints can be "lubricated" and sealed with Teflon® tape.

Polypropylene valves are commonly used in electroless plating due to high resistance to plate-out during prolonged contact with the plating solution. CPVC plastic valves can also be used but they are not as reliable as polypropylene. Stainless steel valves can be used, but require frequent passivation, and may seize due to plate-out of nickel on the valve components.

Operating Temperature

Operating temperature needs to be controlled within 1° F for optimum solution life. The lower the operating temperature, the longer the solution life and the more turnovers can be obtained from an EN solution. However, the lower temperatures tend to yield significantly lower plating speeds. Operating at temperatures that are too high for the process chemistry will also rapidly deteriorate the solution life and may also affect part quality.

Rinsing

Because any foreign ions transferred to the EN tank have a tendency to reduce the solution life, take great care to not only use high purity water, but to also use enough water, so that the drag-in from the rinse tank prior to plating is essentially clean water only. For this reason, high quality deionized water of at least 1 meg-ohm resistance should be delivered to the rinse ahead of plating, and only DI water of equal or better quality should be used to make additions to the plating tank. Enough flow, obtained by calculation of drag-out rates, must be used ahead of the plating tank to prevent long-term contamination. A conductivity controller can be employed to maintain the resistance in the rinse at a level that will protect the process in the long run (typical values are obtained from the EN solution supplier).

Air (low pressure source) or eductor agitation of the rinse tanks is highly desirable to provide good rinsing and low levels of cross contamination. Good mixing is essential with counter-current rinses.

Filtration

Filtration of electroless nickel baths should be continuous, at a porosity of 5 µm or less, and at a rate of 5+ tank turnovers. There are a number of filtration systems available, which can be broken down into two general groups: free flowing and closed chamber.

Bag Filters

Free flowing filters generally use bag-type polypropylene felt bag filters. These filters are usually the most cost effective. Any evidence of solution decomposition will be visible on the bag, alerting the operator to problems in the solution. A commonly seen mis-application of bag filtration is to have the bag above the liquid. If the filter is totally out of the solution, the bag can stretch, creating larger than normal pores in the walls of the bag. The bag should be 1/3 to 1/2 way immersed in the solution.

Cartridge Filters

Cartridge filters can be used on electroless nickel plating solutions as long as the elements are replaced frequently (daily or every other day). Over-use of a cartridge runs the risk of plate-out on trapped particles on the cartridge, which can decompose the solution or cause erratic solution performance. Extended use of a cartridge filter on an unstable solution can cause rapid decomposition with resulting hydrogen buildup in the filtration chamber, which may become a safety hazard.

Filter chambers for bag filters are also available, so that the filter can operate outside the tank. The advantage of quick observation of filtration is lost, however.

Next month we will continue this subject. P&SF