The Care and Feeding of Alkaline Non Cyanide Zinc and Zinc Alloy Generators

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In the distant past, alkaline non-cyanide zinc and zinc alloy baths depended on zinc anodes being located in the plating bath to supply the zinc ions to the plating bath. In some instances, this still goes on today. However, the preferred means of getting zinc ions into the plating bath is by using an offline zinc generating system.

Placing zinc anodes in the plating bath itself has a few inherent problems. Since the anodes are 100% efficient and most alkaline plating solutions are typically around 65-75% efficient, the zinc concentration will tend to increase in the bath. Zinc anodes would also have to be removed during any downtime events to prevent dissolution of zinc into the bath. This of course becomes inconvenient at the very least. Consequently, offline zinc generators have become the common practice of the industry.

Offline generators, when built and operated correctly, have the potential to control the zinc concentration in a zinc or zinc alloy bath (alkaline non-cyanide only) within 0.2 OPG of the target concentration. This results in predictable plating rates, lower addition agent costs and predictable coating distribution.

Offline zinc generators have been in use for many years, however there are certain best practices that can be followed to provide the most effect use of a zinc generator.

The concept of offline zinc generators is the use of a tank that contains a solution of sodium hydroxide and zinc anodes (and often the addition agents). The goal in this system is to encourage a galvanic corrosion cell, which causes the zinc to dissolve electrochemically from the anodes into solution. This solution is then used to replenish the zinc ions to the plating bath, preferably by automatic dosing systems.

In most instances, the rule of thumb is that the zinc generator be approximately 25% of the volume of the plating bath it is servicing in rack applications, and something somewhat larger in barrel operations.

The generator tank should consist of mild steel, but most importantly an unlined tank. The tank itself contributes to the galvanic corrosion cell. Ideally, a heater that can handle the solution composition should also be in the tank, isolated from the tank and not too close to the zinc anodes. The maximum operating temperature should not exceed 110°F, as this will exaggerate the dissolution of zinc. The nominal operating temperature of the generator is best at or around 85°F. Temperatures below 70°F, will result in very low zinc dissolution rates.

The generator tank itself should be set up on non-conductive I-beams off the facility floor, and well away from any metal support structures. This is an effort to mitigate any stray current in the building, which will always interfere with the dissolution of zinc.

The zinc anodes can be affixed to a steel anode flight bar. It is best if the flight bar is designed with pick up loops, so they can be removed by an overhead hoist. The hoist aids in loading, unloading, cleaning and activating the anodes and anode baskets when needed. Anode baskets should consist of mild steel perforated baskets utilizing two (2) channels in each basket. Each channel should be sized to accommodate a zinc anode ball. The dividing channel is best if it is solid steel. This is necessary for the sides and bottom of the baskets as well. This provides the highest level of anode ball-to-steel contact, resulting in maximum galvanic connections. Flight bars should set in saddles on the tank, all consisting of steel. Copper, bronze, plastic and the like are to be avoided, as you want the baskets and tank to be in the galvanic cell. Furthermore, you don't want any copper contamination entering the system from the flight bars or the saddles that hold them.

The anode baskets are best located so that they don't create a wall of anodes. Typically, this means that the baskets are located about 2-3 inches apart and at least 6 inches apart in the direction of travel. Anodes should be staggered from flight bar to flight bar, allowing for maximum mixing of the solution.

Typically, a mechanical mixer is used and is often centered in the middle of the generator tank. Mixer speed should be around 200-250 RPM. Depending on the tank depth, mixers can have multiple impellers to facilitate effective mixing from top to bottom of the solution. Pumps for mixing are not recommended, as they need to produce high flows, with spargers that often end up clogged from any insoluble zinc oxide that may form. Good mixing is critical, as it replenishes fresh hydroxide solution at the anode interface, keeps the anodes active and prevents the coating of the anode balls and baskets of any insoluble zinc. More mixing is better than less mixing.

Anode baskets behave best when they are rusty (higher potential difference between the anode and the basket) resulting in faster zinc dissolution. For this reason, pickling a new basket, rinsing and letting it rust is a good option before use. From time to time, removing the baskets with the hoist and pickling them in a weak solution of HCl, then rusting, will maintain the highest efficiency of the anode basket. With that being said, the system is best designed with a small HCl pickling tank and associated rinse in the generator line allowing for quick pickling and rusting of baskets. It is recommended this be done once every two weeks, to maintain maximum zinc dissolution. Baskets can be removed, rinsed and pickled (just until gassing starts, maybe 30-60 seconds), then rinsed and air dried allowing them to form rust.

The sodium hydroxide concentration of the generator solution is at the recommendation of your zinc additive supplier, but in general concentrations above 19 OPG are NOT recommended, as the hydroxide will prematurely break down the addition agent and slow the generator and the plating bath. The additive supplier can best suggest the optimum concentration, however 12 OPG is the lowest level recommended with 19 OPG being the highest concentration recommended.

The number of anode baskets required to keep up with production can be determined by calculating the efficiency of the plating bath, the number of amp-hours run per day and the number of days run per week. This in turn can be compared to the amount of zinc that is dissolved by each basket in a given time period, resulting in the proper number of baskets needed (and kept full with daily maintenance additions). Most zinc additive suppliers can help you with this calculation.

NOT all zinc anode balls are created equal. Even the smallest trace of the wrong alloyed metal can result in poor zinc dissolution rates. It has been observed that zinc balls using "virgin zinc metal only" have a much faster dissolution rate than those that use scrap metal, or scrap zinc mixed with virgin metal. If the generator is operating very slow, then one may need to consider experimenting with a different anode ball supplier to determine the best anode material for your application.

In most instances, the concentration of zinc in the generator should not exceed 6 OPG. Anything much above that concentration can begin to precipitate out, as you are reaching the limit of solubility (depending of course on hydroxide concentration and temperature).

In some instances, a film of zinc oxide can form on the anode balls and baskets. This if often due to issues around solubility of zinc in solution. Low caustic-to-zinc ratio, low generator temperature and/or high zinc concentrations can cause the zinc to precipitate. This results in isolation of the anodes from the baskets, which leads to a slow down or total halt of the zinc metal dissolution. Excessive use of certain "zinc purifiers" used in alkaline non-cyanide zinc systems can also form organometallic films on the anodes, also isolating the anode balls from the baskets. In any case, removal of these types of films by pickling and rinsing will return the anodes back to operation.

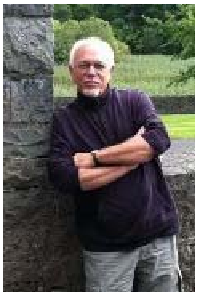
Good ventilation and/or covers are a must, as the dissolution reaction creates airborne caustic mist and coats everything in sight. It is also an irritant with regards to breathing as well as eyes to those that are exposed to the mists. In many cases, generators have a cover that employs a flexible ventilation duct, so that the cover can be removed for anode maintenance. It should be noted that, during the dissolution of zinc, hydrogen gas is evolved and should it come in contact with an ignition source (open flame, spark, excessive heat), hydrogen explosions can occur. Clearly, this is another good reason for good ventilation at the generator tank. As with all handling of chemicals, proper PPE should always be employed.

Automatic dosing can and is recommended for the feeding of the zinc rich generator solution to the plating tank. This is best done with the use of a "time-add" chart. Most zinc suppliers can help create this chart. Automatic dosing is implemented by using amp-hour controlling devices.

In many instances, the auto dosing of the generator discharge flows to the plating tank via gravity. It is best if the generator solution flowing to the plating tank whether by gravity or other means, should pass through a filter before entering the plating tank. This removes any solids that might accumulate in the generator from entering the plating bath, which could lead to roughness. In gravity feed situations, the discharge can be directed to an overflow weir or sump that is picked up by the filter and discharged to the plating bath.

In summary, offline zinc generators aid in effective zinc metal control in alkaline non cyanide zinc plating baths, improving control of the deposit and plating speeds, while eliminating the need to remove zinc anodes from a plating tank to mitigate zinc metal swings. Best practices for operating and caring for a zinc generator result in higher bath performance, better deposit characteristics and reduced plating bath maintenance.

About the author



Steve Kocka has been involved in the finishing industry since 1974. His career spans activity in research and development of membrane keyboard technology where he ultimately migrated into both electronics (PCB fabrication) and later General Metal Finishing. Currently, he is the Business Director, General Metal Finishing North America for Atotech USA, LLC.