Finishing Topics

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Electrodeposited Aluminum

Many years ago when I began a career in electroplating, I received a phone call from a design engineer asking me if I could plate aluminum. I said, “sure,” and told him to bring his prototypes to the lab for processing. A few minutes later, the design engineer placed two steel devices on my desk for plating. He wanted the parts plated with aluminum. I thought he wanted some aluminum parts plated. I did some quick research and found that it was indeed possible to electroplate aluminum, but not from the typical aqueous- (water) based electrolyte. The process requires the use of aluminum salts in non-aqueous (organic) solvent or fused salt baths. We did not have the special equipment required, so we were unable to provide an aluminum coating for the parts.

Recently, I was reminded of this incident when asked once again about depositing an aluminum coating on steel substrates. The customer looked into vacuum deposition of aluminum, but the part geometry and other considerations steered him away from that process. After a few phone calls, I found that the aluminum deposition process was available in Minneapolis, MN. I visited the facility of Alumiplate, Inc., to learn more about the process, and would like to pass along some information about it.

How It Works

The process was developed more than 40 years ago. It was considered too costly for most corrosion protection applications, however, because electrodeposition requires the exclusion of oxygen, carbon dioxide and moisture from the organic solutions. Today’s baths consist of aluminum alkyl and sodium or potassium fluoride dissolved in toluene. The anodes are of high purity aluminum and dissolve during the electrolytic processing. The coating produced is quite pure: 99.99+ percent. This is purer than the anode material because anode contaminants are insoluble in the electrolyte, and are continuously removed from solution by filtration. Because the electrolyte must be protected from moisture and air, all plating is done in a closed cell, with the parts to be plated entering through an airlock or vacuum chamber. The bath operates at 100 °C and 100-percent cathode and anode current efficiency.

Typical plating is done utilizing racks, but bulk plating is possible with special equipment. The aluminum is deposited using periodic reverse-pulse plating, with an average current density of 1.0 A/dm^2 (9.3 A/ft^2). Parts to be plated are first cleaned and pickled in aqueous solutions as in conventional electroplating. Because it is absolutely necessary to prevent contamination of the electrolyte by water or oxygen, the parts must be treated in dewatering fluids before entering the aluminizing cell. The dewatered parts enter the cell through an airlock, and are dipped into a solvent to remove the dewatering liquid before being placed into the aluminization bath. Currently, ferrous parts are given a flash (1–2 µm) of nickel (or copper) to improve the adhesion of the aluminum layer. Normally, an aluminum layer thickness of 12 µm is sufficient for most applications, and can be deposited in about one hour. It is possible to reach a thickness of 500 µm of aluminum if needed for special applications. After aluminum plating, the parts are rinsed in a solvent to remove any traces of the electrolyte.

Characteristics Of Aluminum Plating

Because the layer is high purity aluminum and is pore free after a thickness of 8 µm is reached, additional processing, such as bright-dipping, polishing, chromate conversion coating, or anodizing is possible. The aluminum layer itself acts as a sacrificial anode to provide galvanic corrosion protection for most metals. Another feature of the aluminum plating is corrosion protection at temperatures as high as 1,000 °F. A 12 µm coating, with yellow chromate conversion coating, will provide 1,000 hr of five percent neutral salt spray resistance. The plating bath has excellent throwing power, similar to that of cadmium cyanide. The aluminum plating can replace cadmium plating for applications where lubricity is not a primary concern. Parts with complex geometries will receive a uniform aluminum coating, but special racking and the use of auxiliary anodes may be necessary. The aluminum coating is quite ductile and parts can be formed after plating. Although the aluminum bath coating is non-leveling, it can be physically or chemically polished after plating for applications requiring a shiny surface appearance for reflectivity.