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Anodizing is a process through which a metal's natural oxidative coating is strengthened, and in doing so furnishes increased durability and resistance to corrosion. It can be used on a wide variety of metals, including titanium, zinc, magnesium, and niobium, but the most common application is on aluminum alloys. A relatively environmentally friendly process, anodizing hardens metals in everything from mp3 players and gun parts to telescope and car components.

When cut, aluminum and other metals react with oxygen to form a tough, natural external coating of oxide on the fresh surface; in certain metals, such as iron and carbon steel, this oxidation process manifests itself as rust, increasing the susceptibility of the metal to corrosion. Anodizing takes this coating a step further to toughen, harden and otherwise protect the metal surface by artificially producing a thicker and more durable layer of oxide. Due to its microscopic porous nature, it adheres better to glues, dyes and pigments. Once sealed, anodized metals, particularly aluminum, form a strong, durable, and cosmetically manipulable surface that can withstand corrosive forces and be used in a wide variety of products, allowing for diverse application.

The Anodizing Process

It its most basic sense, anodizing involves placing a cleaned alloy part in a heated electrolyte solution—usually a sulfuric acid bath for aluminum—and connecting it to an often steady, but sometimes pulsing DC circuit, causing the alloy part to become the *anode*, or positive electrode, hence the name. The negative electrodes, the cathode, begins releasing hydrogen, while the reverse flow of electrons from negative to positive picks up oxygen from the acid and begins forming the oxidized surface. The variables in the process include using different chemical baths, voltages and currents, bath temperatures, soak times and post-anodizing treatments.

Equipment

The process of anodizing is similar to electroplating, and requires the same basic equipment of charge, bath, and connectors. Different classes of gear are available from full industrial-scale equipment down to garage setups for the , and vary mostly in size and automation capability. As in other metal treating processes, the metals must be cleaned beforehand, either chemically or mechanically. Grease and oils must be removed, as well as old finishes. Lye baths will remove old anodized surfaces and paint coatings must be sandblasted clean.

For the anodizing process itself, tanks hold the electrolytes into which the parts are immersed. Tank materials include PVC and polyethylene plastics as well as stainless steels—the hobbyist can even use coolers. Other needed equipment includes tank heaters, a well-regulated DC power supply, and expendable cleaning, rinsing and sealing chemicals.

Electrolytes

Electrolytes are the conductive baths used in anodizing that allow for the pickup and release of oxygen to the coating of the part. Different electrolytes are used to produce different coatings in anodizing with chromic and sulfuric acids often supplying the ingredients. With these two electrolytes, three distinct types of anodizing are possible.

Chromic Acid (Type I)

The first electrolyte to be used in anodizing, chromic acid is still widely used on aircraft exteriors either alone or as a corrosion inhibitor prior to painting. When joined components such as riveted plates need anodizing, chromic acids are used so if the acid seeps into the crevices of the joints, it won’t continue to eat away at the alloy. The thickness of the coating is less than that when using other acids, which can be a plus when strict tolerances come into play. Chromic acid electrolyte anodizing can also serve as a pre-treatment to gluing aluminum parts, as it increases the pore sizes on the surfaces. The color of a chromic acid treated part is clear to gray.

Sulfuric Acid (Types II and III)

Sulfuric acids are more widely used in anodizing than any other electrolyte, and serve as conventional coatings and also hard-coat. As a conventional anodizer, (Type II) it produces a thicker and more durable coat than chromic acid treated parts and is more compatible to coloring.

As a hard-coat treatment (Type III), sulfuric acid is also used as the electrolyte. Hard coating is performed at very low temperatures (28 to 32 degrees F) and at higher acid concentrations than in Type II anodizing. A small addition of powdered aluminum is also added to the electrolyte solution in the hard-coat process. Parts that are hard-coated include internal combustion engine pistons, cylinders and cams. Many parts formerly made of steel can be substituted with aluminum, which saves on machining time and costs, and cuts down on component weight. Hard coating also creates low friction and a low wearing shell, making it ideal for bearing surfaces and metal joints. On aluminum threads, a hard anodizing coat will eliminate galling, which occurs as friction between the male and female threads breaks down the original oxide coating on untreated aluminum.

Other Electrolytes

Phosphoric and boric acids are other electrolytes used in anodizing for specialty purposes. Boric acids, for example, produce a pore-free coating, which can be used in film coatings where pores would be too thick.

Alternative Methods

Besides batch anodizing, where individual pieces are carried from cleaning tanks to anodizing tanks to sealer tanks, anodizing can also be performed in a process called continuous coil anodizing, wherein a coil of aluminum is unwound, processed through each tank and wound again on the end spool. Just as in batch anodizing, continuous coil anodizing is flexible enough to allow coloring.

Continuous coil anodizing is used when large pieces are needed in architectural structures such as column covers and building facades. When anodized stampings are needed, it saves time over having to coat each part individually and is more consistent. One disadvantage is that when stamping out parts from anodized sheets, the edges of the stampings will not be coated.