Fort Wayne Anodizing

Reference Manual

It’s not how it’s made. It’s how it’s made to last.
Introduction to hard anodizing

It has long been known that reactive metals and alloys can be protected from corrosion and deterioration by the application of a coating of an unreactive material. Such a protective coating can greatly extend the use of the metals and alloys.

In the case of aluminum, the development over the past two decades of hard anodizing as a protective coating has permitted uses of the metal far beyond those envisioned by its discoverers. Because hard anodizing prevents galvanic reaction, aluminum can now be used with such diverse metal components as steel, brass, and bronze. Hard anodizing also enhances many of the desirable properties of aluminum: low density, excellent electrical and thermal conductivity, and good malleability and ductility.

Hard anodizing is not to be confused with ordinary anodized aluminum, in which a very thin coating of aluminum oxide is developed only on the surface of the metal. Hard anodizing requires a special electrolysis process which produces a dense layer of aluminum oxide both on and in the aluminum surface. The thickness of this hard anodizing coating ranges from 1 to 3 mils or more.

Aluminum oxide is an inert, stable compound. As a coating, it imparts this inertness to the aluminum surface. It is well known as an abrasive corundum and is hard as such gemstones as sapphire or ruby. Because it distributes heat evenly and efficiently, it can be used as a coating of high temperature material for industrial furnaces.
Properties of hard anodic oxide coatings

HARDNESS

Wear characteristics compare favorably with hard tool steel under low loads. Microhardness tests on hard anodized aluminum typically give values of 500 to 530 VPN. This number refers to the weight required for a diamond indenter to produce an indentation in the coating.

Microhardness is nearly independent of coating thickness, up to 1.5 mils. For example, the hardness of an aluminum coating of 450 VPN will exhibit the same wear characteristics as tool steel which has twice the microhardness of aluminum hard coatings.

WEAR RESISTANCE

Wear resistance is measured by the weight of an abrasive required for a controlled pressure jet to blast through the coating. Hard coatings exhibit a wear resistance over ten times that of ordinary anodized aluminum. In the standard Tabor abrasion tester, hard anodized aluminum exhibits only half the wear that cyanide case hardened steel shows after 50,000 cycles in the abrasion tester. When the test is extended to 100,000 cycles, the superiority of hard anodized aluminum is even more vividly illustrated. The surfaces of 4130 steel, mild steel, and chrome hardened steel show greater wear than hard anodized aluminum.

While the measurement of microhardness and abrasion is useful to compare with steel, it does not as accurately reveal the frictional behavior of other materials compared with hard anodized aluminum. A far more useful test is the rotating wheel, in which one surface is abraded by another on a rotary wheel. When steel is used on the abrading wheel, hard anodized aluminum exhibits virtually no wear, even after 120 hours.

APPEARANCE

As coating thickness increases, color varies from colorless to light brown on pure aluminum from 1 to 5 mils thickness. Alloys vary in color depending on alloy composition, usually from tan to jet black for 1 to 3 mils thickness.
UNIFORMITY

In the hard anodizing process, the coating follows the contour of the part with uniform build up. Holes build up the same thickness as the exterior. This allows for precise control of very close tolerances critical in many applications.

Surface roughness, which increases depending on individual application, alloy and coating thickness, can be honed smooth. Due to excellent throwing power obtained in the hard anodizing process, hard anodizing effectively coats unusually shaped parts.

HEAT RESISTANCE

The inert nature of the anodic coating gives excellent heat resistance. In fact, hard anodized coatings are used in the aeronautics and space industry for ailerons and exposed rocket components. Hard anodized parts have shown no effect after short exposures to temperatures as high as 2000 degrees centigrade. Although coating thickness is not a major factor in heat resistance, exposure to direct flame has shown that thicker coatings provide a longer life for the exposed part.

THERMAL PROPERTIES

Hard anodized coatings exhibit very low thermal conductivity and expansion. This property makes the jet black coating ideal for use in solar collectors, without additional paint. Pistons for internal combustion engines are hard anodized to minimize the amount of thermal expansion in relation to possible thermal expansion of the engine block.

ELECTRICAL PROPERTIES

Because aluminum oxide is an excellent electrical insulator, hard coated aluminum and its alloys can be used as electrical insulators. The high temperature stability of the coating permits operation up to 500 degrees centigrade (unlike many other dielectrics in which voltage breakdown decreases markedly with increasing temperature). Anodic coatings typically exhibit a voltage breakdown of 900 to 1000 volts/mil, a dielectric constant of 6.4 to 6.6, and resistivity from $10^{14}$ ohm cm to 200 degrees centigrade. This resistivity is of the same order of magnitude as glass and porcelain.

These properties make hard anodized aluminum an excellent insulation mounting for electronic components. In power transistor mountings, for example, anodized aluminum provides a lower operating temperature and longer life.
LUBRICITY

Any hard anodized surface has a high degree of lubricity. For instance, in certain applications hard anodized surfaces can run against other hard anodized surfaces without lubrication. Ice will not stick to hard anodized surfaces. Impregnated with solid lubricants such as PTFE (Teflon®), hard anodized aluminum surfaces have an even lower coefficient of friction.

CORROSION RESISTANCE

The inert nature of the coating provides excellent corrosion resistance. Hard anodized coatings typically pass the 1000 hour 5 percent salt spray test (ASTM B-117). Under other special sealing applications, hard anodizing has been known to resist corrosion in excess of 50,000 hours.

Suggestions

The following specific points may be useful as you make plans for hard anodizing your parts.

TERMINOLOGY

Because hard anodizing penetrates the base metal, “thickness” includes both the build up and the penetration. Use the phrase “build up per surface” when requesting hard anodizing to avoid misunderstanding.

COMPATIBILITY OF FINISHES

If there is a requirement for hard anodizing and any other type of chemical processing, please contact Fort Wayne Anodizing for recommendations.
Most aluminum alloys can be hard anodized easily. However, difficulties can arise if an order of parts is manufactured from different alloys and this fact is not known to the anodizer. Different alloys build different rates of coating thickness. Consequently, if different alloys are processed at the same time, different hard coat thicknesses are formed on each alloy. The result can be in an out of tolerance condition in some parts. It is imperative that the alloy always be designated prior to hard coat anodizing.

Fort Wayne Anodizing will always coat to the specifications furnished with each order. It is entirely the responsibility of the manufacturer to make sure that the correct information for hard anodizing accompanies the work order.

Before machining parts, be sure that you are allowing for hard anodizing build up and not a plating build up. Standard tolerance is +/-0.0005 on a coating thickness of 0.002. If closer tolerance requirements are needed, please consult Fort Wayne Anodizing in advance.

Allowing a tolerance on coating build up means you must machine the part closer than blueprint specifications. For example, a round bar finished at 1.500 +/-0.001 which is to be hard coated 0.002 +/-0.0002 thick (0.001 +/-0.0001 build up per surface), should be machined to 1.498 +/-0.0008.
Experience has shown that certain abrasive wheels and compounds are suitable to critical dimensions or very fine finishes.

**Coolants** - Most grinding should be done wet using a water coolant and a good soluble oil mixed approximately 100 to 1.

**Surface Grinding** - Grit sizes of 80 to 120 will give surface finishes of 8 to 2 micro-inch. Wheels (soft) in the H, I, and J grades are preferred. These wheels will permit fast removal with less danger of burning or cracking the work.

**Internal Grinding** - A fine grit wheel produces the best results.

**Cylindrical Grinding** - This is done with a finer grit wheel that is free cutting but capable of producing a very fine finish.

**Polishing or Lapping** - This is best performed by using a baron carbide abrasive (or equal) mixed with a heavy oil or petroleum jelly. Polishing sticks or brushes are recommended for grit size from 400 to 1200, depending upon the finish required.

**Conclusion**

The number of applications for hard anodized aluminum continues to increase rapidly. Considering its range of unique benefits, any manufacturer or user of engineering equipment would be wise to examine whether hard anodized aluminum could profitably and advantageously replace existing parts.
Anodizing and chromate conversion capabilities

TRADITIONAL ANODIZING LINES
Clear and Colors:

Line #1:
10' long x 44" wide x 48" deep

Line #2:
10' long x 47" wide x 48" deep

Etch and Clear:

Line #3:
22' long x 22" wide x 52" deep

Line #4:
22' long x 22" wide x 52" deep

Color Dye Tanks:
Black:
96"long x 48"wide x 48"deep

Green:
43"long x 30"wide x 44"deep

Blue:
35"long x 35"wide x 42"deep

Red:
32"long x 30"wide x 42"deep

Gold:
41"long x 42"wide x 39"deep

Brown:
42"long x 30"wide x 44"deep

Yellow:
42"long x 30"wide x 44"deep

Violet:
42"long x 30"wide x 44" deep

Pink:
42"long x 30" wide x 44" deep

FULLY AUTOMATED HARD COAT ANODIZING LINES
16' long x 3' wide x 5' deep

CHROMATE CONVERSION LINES
Line #1:
22' long x 20" wide x 52" deep

Line #2:
42" long x 41" wide x 48" deep

IMPREGNATION LINES
35" diameter x 47" deep
Fort Wayne Anodizing can certify to the following:

**HARD ANODIZING**
- MIL-A-8625, Type III, Class 1 & 2
- MIL-STD-171B, 7.5
- MIL-A-63576-A (Hard Anodizing with PTFE) Teflon®
- AMS-2468
- AMS-2469

**CONVENTIONAL ANODIZING**
- MIL-A-8625, Type II, Class 1 & 2
- MIL-STD-171B, 7.2, 7.2.1, 7.2.2
- AMS-2471
- AMS-2472

**CHROMATE CONVERSION**
- MIL-STD-171B, 7.3, Chromate
- MIL-C-5541, Class 1A, Class 3
- AMS-2473

**IMPREGNATION OF POROUS MATERIALS**
- MIL-STD-276, Nonferrous Metal Castings
- MIL-I-17563B, Aluminum, Copper, Iron, Magnesium and Zinc Castings
- MIL-I-13857A, Impregnation of Metal Castings
- MIL-I-6869D, Impregnants for Aluminum Alloy and Magnesium Alloy Castings
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