Anodizing Aluminum

Anodizing, or anodising in British English, is an electrolytic passivation process used to increase the thickness of the natural oxide layer on the surface of metal parts. The process is called "anodizing" because the part to be treated forms the anode electrode of an electrical circuit. Anodizing increases corrosion resistance and wear resistance, and provides better adhesion for paint primers and glues than does bare metal. Anodic films can also be used for a number of cosmetic effects, either with thick porous coatings that can absorb dyes or with thin transparent coatings that add interference effects to reflected light. Anodizing is also used to prevent galling of threaded components and to make dielectric films for electrolytic capacitors. Anodic films are most commonly applied to protect aluminum alloys, although processes also exist for titanium, zinc, magnesium, niobium, and tantalum. Iron or carbon steel metal exfoliates when oxidized under neutral or alkaline microelectrolytic conditions; i.e., the iron oxide (actually "ferric hydroxide" or hydrated iron oxide, also known as rust) forms by anoxic anodic pits and large cathodic surface, these pits concentrate anions such as sulfate and chloride accelerating the underlying metal to corrosion. Carbon flakes or nodules in iron or steel with high carbon content (high carbon steel, cast iron) may cause an electrolytic potential and interfere with coating or plating. Ferrous metals are commonly anodized electrolytically in nitric acid, or by treatment with red fuming nitric acid, to form hard black ferric oxide. This oxide remains conformal even when plated on wire and the wire is bent.

Anodization changes the microscopic texture of the surface and changes the crystal structure of the metal near the surface. Thick coatings are normally porous, so a sealing process is often needed to achieve corrosion resistance. Anodized aluminum surfaces, for example, are harder than aluminum but have low to moderate wear resistance that can be improved with increasing thickness or by applying suitable sealing substances. Anodic films are generally much stronger and more adherent than most types of paint and metal plating, but also more brittle. This makes them less likely to crack and peel from aging and wear, but more susceptible to cracking from thermal stress.[1]

Objectives

- To successfully anodize and dye aluminum.

Materials

(* - indicates purchase)

- Computer
- Vernier temperature probe
- Vernier current probe
- Vernier pH probe
- Steel wool
- Nitrile gloves
- Thick rubber gloves
- Protective eyewear
- Dishwashing detergent
- Distilled H2O (at least 10 gallons)
- *2000W Immersion heater

[1] http://en.wikipedia.org/wiki/Anodizing

- *5x Screw-top pails, 3.5 gal, to seal and contain hazardous chemicals
  - http://www.uline.com/BL_8173/Screw-Top-Pails
- Simple green, Loctite Natural Blue, or similar degreaser
- *SP Cleaner
  - http://www.caswellplating.com/sp-cleaner-10-lbs-makes-20-gal.html
- Lye (NaOH) powder, at least 4tbsp
- *desmut/Deoxidizer
  - http://www.caswellplating.com/electroplating-anodizing/anodizing-products/anodizing-accessories/aluminum-deoxidizer-desmut-1-quart.html
- *Battery acid, 1-5gal (pick up at NAPA auto parts in Phila.)
  - http://www.napaonline.com/Catalog/CatalogItemDetail.aspx?R=NBP9000_0006559869
- Baking soda to neutralize spilled sulfuric acid
- Aluminum lead wire with eye hooks attached
- *Aluminum or titanium wire, 12AWG. Aluminum will only be good for 1 use as it will anodize, titanium is reusable.
  - Aluminum (42'): http://www.mcmaster.com/#metal-wire/=hd1y65
  - Titanium (2x6'): http://www.caswellplating.com/electroplating-anodizing/anodizing-products/anodizing-accessories/tw2.html
- Aluminum angle to make rack
- Power supply
- 6061 Aluminum plate to use as cathode with hole for bolt-on wire connection
- Ice in a container to cool off anodizing mixture if temperature exceeds standard and to cool water for rinse after anodizing
- *Casewell dye
  - http://www.caswellplating.com/electroplating-anodizing/anodizing-products/anodizing-dyes.html
- *Sealer
  - http://www.caswellplating.com/electroplating-anodizing/anodizing-products/anodizing-accessories/anodizing-sealant-1-lb.html

Procedure

NOTE: Mark solution level in each of the containers to be able to compensate for water lost to evaporation.

Cleaning:

1. Use steel wool to pre-clean and polish aluminum for a matte finish.
2. Put on nitrile gloves and wash hands. Put on protective eyewear.
3. Clean parts with dishwashing detergent and distilled water using a brush or sponge. Rinse with DH2O.
4. Degrease parts with Simple Green or similar degreaser. Rinse with DH2O.
5. Clean parts using an anodizing degreaser such as Caswell SP cleaner.
   1. 1:2 ratio (2 lbs SP cleaner make 4 gallons), mix SP cleaner with DH2O
   2. Warm solution to 110°F
   3. Immerse parts for 3-10 minutes.
   4. Rinse with DH2O
6. Create an even finish on the parts by immersing them in a lye etch solution
   1. 2:1(tbsp:gallon ratio)

2. Immerse parts for 30m
3. Rinse with DH2O

7. *At this point, water should flow smoothly down the face of the Al without beading up.*
8. Desmut parts using Caswell Deoxidizer/Desmut
    1. 1:8 ratio (1 quart mixes with 2 gallons of DH20)
    2. Warm solution to 70-110°F (room temperature)
    3. Immerse parts for 1-3 minutes
    4. Rinse with DH2O

Anodizing:

1. Using Al wire, suspend each of the Al parts from the rack so that they will be fully immersed in the anodizing solution.
    - Make sure the connection is tight as a lost connection will not anodize.
    - Where the aluminum touches the part, the part will not anodize
2. Place all anodizing equipment in a vented fume hood
3. Prepare anodizing bath using battery acid and DH2O
    1. Put on rubber gloves and eye protection
    2. 1:1ratio (1 gallon DH2O mixes with 1 gallon battery acid)
    3. ***Add acid to water***
4. Connect the rack to the powered-off power supply
5. Place the 6061 Aluminum cathodes in the tank, 2 on either side and connect it to the negative terminal of the powered-off power supply.
    1. Place the cathode in the tank with part sticking out so heavy gauge wire can be connected.
6. **NOTE: a test part should first be anodized to achieve the proper dissolved aluminum concentration for anodization as well as calibrate the system to run at 12 ASF**
7. Calculate voltage, amperage, and time for anodization:
    1. Anodize at a current density of 12 amps per square foot (ASF) with voltage of 15-20VDC for the calculated amount of time.
    2. The bath should not exceed 75°F while anodizing, ideally between 68-73°F.
8. Suspend the aluminum part in the acid solution, hanging the wires from a rack
    1. The part should not touch the sides of the container
    2. The part should not be too close to the cathode
9. Connect the positive terminal of the power supply to the rack holding the part(s) and turn on the power supply.
10. Turn on the power supply and slowly increase the voltage until required current is reached.
    - The current should rise and then level off during the first few minutes of anodizing.
    - **NOTE: A sudden drop in current early in the process indicates that the connection to part has failed.**
    - **If current continues to rise as the parts anodize, check the temperature. The hotter the acid, the more current it draws.**
11. Let the anodization process run for the calculated duration of time, monitoring the temperature and current
12. Once the anodization time is complete, rinse the part with **ice cold** distilled water.

Dying:

1. Mix dye according to manufacturer's instructions
   - For Casewell dye, 1:32 (mix 4 oz dye with 2 gal. distilled water)
2. Heat the dye to 140°F
3. After thorough rinsing in distilled water, immerse the part in the dye at a temperature of 140°F for 15 minutes
4. Suspend and immerse fully each part in the dye
5. Let part sit in die for 15 seconds - 15 minutes depending on shade desired.
6. Rinse the parts using distilled water.

Sealing:

1. Mix sealer according to manufacturer's instructions
   - For Casewell Nickel Acetate based sealer 1:32 (mix 1 oz to 1 gal. of distilled water)
2. Heat the sealer to 210°F
3. After thorough rinsing in distilled water, immerse the part in the sealer at a temperature of 210°F for 5-30 minutes.
4. Rinse with distilled water
5. Let part dry overnight.