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"Guide to Commonly Used Hardcoat Anodizing Processes"

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Aluminum Anodizers Council • 1000 N. Rand Road, #214 • Wauconda, IL 60084 USA
Tel: 847/526-2010 • Fax: 847/526-3993 • mail@anodizing.org • www.anodizing.org

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Guide to Commonly Used Hardcoat Anodizing Processes

Purpose and Use of this Guide as a Reference

The purpose of this guide is to list as many useful facts as possible about the most common processes used today in North America and in Europe. The heart of the information appears as a table of processing facts about these processes. A section of "Notes" is included in order to list some additional general and specific information about hardcoat anodizing.

The bulletin may be useful to the experienced hardcoat anodizer as well as the novice. Veteran anodizers may want to refer to it to reinforce their understanding of the principles and processes involved in hardcoat anodizing. The neophyte may use the guide as a starting point from which to ask questions and ascertain further knowledge as a first step in learning about the hardcoating processes. A bibliography of the reference materials used in helping to prepare this bulletin is also included.

Notes and General Information about Hardcoat Anodizing

Major specifications used for hardcoat anodizing are:

- MIL-A-8625 (latest version).
- AMS 2468C. The automotive (SAE) equivalent of 8625
- BS 5599:1978. The British Standard
- BAC 5821C. Boeing Specification

where MIL-A-8625 is the standard used for hardcoating in the USA and Europe. It is important to notice that this standard does not restrict processing conditions, as long as the hardcoat passes the performance tests required in the standard.

The best hard anodized finish is the finish whose processing variables are engineered to result in an adequate anodic coating for the intended service.

The most important issues when hardcoating aluminum are the alloy and temper of the parts being anodized and the processing variables. There are many combinations of these variables. Each has its unique set of processing conditions that work best for the product application.

Some of the most common processing variables and some useful facts are found below. These are divided into four groups; notes about the solution, notes about the voltage, notes about the current and notes about the properties of the anodic coating. These are general statements. Not every statement is true in every case.

Solution

1. The dissolved aluminum content of the bath is routinely controlled within a range of 2 to 8 g/l.
2. Normal sulfuric electrolyte concentration is 15% to 20% (165 g/l to 220 g/l) by weight. Higher acid concentrations (20% to 30% by wgt, or 220 g/l to 330 g/l) yield lower voltage at any given current density. Use of organic additives such as oxalic acid, glyoxalic acid, glycolic acid and glycerin help offset the relatively aggressive coating dissolution caused by the high acid concentration.
3. The same is true for higher bath temperature.
4. Higher acid concentration and/or higher temperature are often used when processing alloys higher in copper. A common practice in this case is to use lower current density for the first 10 – 15 minutes in order to build a more uniform coating, and then increase current density to approximately 28 – 30 amps per square foot (a.s.f.).

5. An increase of bath temperature yields an increase in electrolyte conductivity, which results in slightly decreased voltage for a given current density.
6. Oxalic acid and other organic additives to the bath tend to give smoother anodic coatings than a bath with no additives.
7. Vigorous agitation of the electrolyte is required for high current density processing. Acceptable means of solution agitation include the use of clean, dry, low pressure air. The electrolyte can also be agitated by using a pump or by pumping the solution through eductors to multiply the agitation effect. Mechanical movement of the load itself may also be used as a means of agitation. These mechanisms may be used individually or in combination.

Voltage

1. Constant current method of voltage control gives the best and most predictable coating thickness results.
2. Generally, the combination of lower voltage, higher temperature and higher bath concentration results in lighter colored coatings.
3. Higher voltage, not higher current density, results in larger anodic pores. This reduces coating porosity and results in a higher density, harder coating. There are unique processes that operate outside these parameters, using lower voltage, which can also give higher abrasion resistance under some circumstances. (See the table for more detail.)
4. Voltage is responsible for color and hardness; amperage (current density) is responsible for coating thickness. This is the case for any given alloy and temper of aluminum and given bath conditions. All other processing conditions being equal
    - Higher voltage gives better wear resistance,
    - Higher current density results in thicker coatings per unit of time.

Current

1. Straight DC can be used quite successfully with the so-called conventional alloys that are not high in copper such as 6063, 6061, 3003 and 5052.
2. Pulsed DC output and AC superimposed on DC output have some advantages over straight DC power when processing, particularly, high copper alloys. The lower voltages used in these modes of power can result in fewer problems due to burning of the parts.
3. Pulsed DC may also be used to influence the abrasion resistance properties of the anodic coating.
4. Pulsed DC uses higher current densities at lower voltage than conventional DC. This results in thicker coatings without burning on high copper alloys.
5. Modified waveforms of power output may have advantages when used on 2XXX series alloys as well as certain casting alloys.

Properties

1. Generally, abrasion resistance increases with lower temperature and higher voltage.
2. The anodic coating builds perpendicularly to the aluminum substrate. Therefore, sharp edges on the parts tend to result in edge voids in the coating.
3. Edge radii should be approximately 1/16" (.0625") per mil of anodic coating required.
4. Sealing of hard anodic coatings usually results in greater corrosion resistance and higher coating dielectric. Sealing may also lower the abrasion resistance somewhat.
5. Generally, the thickness of the hard anodic coating is half penetration into the base metal and half buildup, but the exact ratio depends primarily on alloy and temper of the part.
6. Different alloys produce different anodic coating characteristics. High silicon content can affect the density of the anodic coating.

Bibliography

References:

1. The Surface treatment and Finishing of Aluminum and its Alloys, Fifth Edition Vol. 1, S. Wernick, R. Pinner, P. G. Sheasby; Finishing Publications Ltd., Teddington, Middlesex, England, 1987.

2. The Technology of Anodizing Aluminum, A. W. Brace, and P.G. Sheasby; Technicopy Limited, 66 High street, Stonehouse, GL10 2NA, England, 1979.

3. The Technology of Anodizing Aluminum, Third Edition, Arthur W. Brace; Interall S.r.l., Modena, Italy, 2000.

4. Instructions for applying Alcoa Alumilite Finishes, Aluminum Company of America, Pittsburgh, PA, 1956.

5. Multipurpose Anodizing Electrolyte (MAE) Technical Manual, Reynolds Metals Company, Richmond, VA, 1968.

6. Hard Anodizing of Aluminum, A. W. Brace, editor; Technicopy Limited, 66 High street, Stonehouse, GL10 2NA, England, 1987.

7. Technical bulletin #3-00, Aluminum Anodizers Council, 1000 N. Rand Road, #214, Wauconda, IL 60084, U.S.A., 2000.

Table 1
Commonly Used Hardcoat Anodizing Processes

Process	Electrolyte	Current Density a.s.f (a.s.d.)*	Voltage	Temp. F (C) ±2	Time (Minutes)	Seal Options	Comments
Alcoa 225/226 (Wrought alloys)	12% (132 g/l)† sulfuric acid + 1% (10 g/l) oxalic acid	36 (3.9)	40 - 50 DC	50 (10)	20 - 40	None required	Coating builds @ 1.0 mil/20 minutes. Higher dielectric obtained w/duplex seal of NiAc then, sodium dichromate.
Alcoa 725/726 (Castings)	Same as 225/226	Same	Same	Same	Same	Same	For cast alloys compatible with anodizing.
Martin (MHC)	15% (165 g/l) sulfuric acid	24 - 30 (2.6 - 3.9)	40 - 60 DC	32 (0)	1.5 mil / hour	None required	For thicker coatings on certain alloys than Alcoa Alumilite process. Higher dielectric obtained w/duplex seal of NiAc, then sodium dichromate.
Reynolds MAE	18% - 22% (200-240 g/l) sulfuric acid + 2% - 4% (vol) glycerine and glycolic acid	24 - 30 (2.6 - 3.9)	30 - 40 DC	70 (21)	1.0 mil/30 minutes @ 24 a.s.f.	Optional. Depends on application	Produces clear hard coatings capable of adsorbing dye. 1:1 mixture of glycerine and glycolic acid = 2 parts (vol) glycerine + 3 parts (vol) glycolic acid.
Sanford Classic	300 g/l + additive "Sanfran" ~5% by volume…	up to 40 (4.3)	40 - 65 DC	30 (-1)	2.0 mil/50 minutes	None required	Can be used for "high copper" and "high silicon" alloys.
Sanford Low Voltage	200-300 g/l + additive "Sanfran" ~5% by volume…	up to 120 (12.9)	12-18 DC	45-70 (7 - 21)	2.0/15 minutes	None required	Can be used for any available al.alloys and for organic and 2-step (electrolytic) color hard anodizing.
Hardas	10% - 20% (110-220 g/l) sulfuric acid	12 - 60 (1.3-6.5) DC and 6 - 30 (0.6-3.2) AC	Up to 90	25 - 30 (4 to -1)	"Rapid film growth"	None required	Used primarily in U.K.
Common Hardcoat Process Variations							
High Copper Alloys I	15% (165g/l) sulfuric acid	15 (1.6) 10 - 15 minutes, then 24-30 (2.6-3.9) balance	40 - 50 DC	50 (10)	2.0 mil in 90 minutes	None required	Many processing techniques and variables are possible to achieve desired results.
High Copper Alloys II	23% (250 g/l) sulfuric acid	20 - 24 (2.2 - 2.6)	30 - 40 DC	30 - 50 (-1 to 10)	variable	As desired	
Alcoa Alumilite	7% (77 g/l) sulfuric acid + 1% - 4% oxalic acid	24 - 30 (2.6 - 3.9)	60 - 80 DC	30 - 35 (-1 to 2)	approx. 1.0 mil/hour	None required	Produces very hard, but relatively rough coatings.

* a.s.f. = amps per square foot; a.s.d. = amps per square decimeter

† g/l = grams per liter