DANCO
Medical

TITANIUM ANODIZING

The Finish of Choice for Orthopaedic Implants

Introduction
Titanium anodizing provides products with improved properties compared to those in a raw or "unfinished" state. Test data validates numerous mechanical benefits, and observation with a 10x eyepiece reveals the leveling effects of the process. Scars from machining and/or deburring are 'leveled' into a continuous, smoother, gray-colored surface. The two most common types of treatment are *Type 2 anodizing* and *color anodizing*.

Type II Anodizing
Anodic treatment of titanium and its alloys (Type 2 anodization) is typically performed in accordance with SAE International's AMS 2488 Standard. The process is covered under an Aerospace Material Specification, as it was first developed for treatment of parts associated with the air and space industries. Advantages associated with the Type 2 titanium anodizing process include increased lubricity, antigalling, and increased fatigue strength. As these advantages have become increasingly apparent, the popularity and acceptance of this coating have grown considerably within the medical device industry, especially in terms of its applicability to the finishing of orthopedic implants. The anodization process accelerates the formation of an oxide coating under controlled conditions to provide the desired result. Since the coating is biocompatible as well as nontoxic, the process lends itself to achieving drastic improvement in implant performance.

The coating is created using various electrolytes, whereby the devices are made positive (anodic), with a corresponding negative (cathodic) terminal attached to a D.C. power supply. As the process creates a penetrating coating, there is no measurable dimensional change when measured with a micrometer accurate to 0.0001 inch (2.5 ∝m). Quality inspection (100% visual) is performed on completed parts.

Controlling factors that impact the end result include: cleaning and surface preparation; solution limits and control; voltage limits and control; temperature limits and control; and post-anodizing treatment and packaging.

Benefits of Type 2
• produces anti-galling and wear resistant surface properties
• increases fatigue strength up to 20% due to the homogeneous surface treatment
• improves surface finish by 50% or greater without special vibratory or burnishing processes
• increased lubricity enhances mateability of moving parts, thus reducing erosion/abrasion, and reduces fretting
• high strength-to-weight ratio improves fatigue properties, yields excellent corrosion resistance
• coating is continuous, smooth and adherent, without 'flaking' in highly stressed areas
• coating can be welded to, or over
• characteristically gray color of anodized titanium is easily distinguishable from stainless steel

Applications
Products for which titanium anodization is applicable range from orthopedic and dental implants, to undersea mateable connectors, to aerospace components. Within the orthopaedic industry, products for which this type of treatment is often applied include bone plates and screws, intramedullary nails and rods, spine "cages," and other hardware commonly associated with trauma or spinal surgery.

Titanium screws: anodized screw on left

Color Anodizing
The second type of titanium anodizing treatment commonly applied within the device industry is color anodizing. Unlike Type 2 anodizing, there are no governmental or regulatory bodies that have issued specifications relative to color anodizing. Consequently, numerous proprietary processes abound that might only be referenced on customer 'prints'—a situation that frequently causes confusion for OEMs when

attempting to describe a process. For example, Danco uses proprietary documentation to detail its color anodizing process, in conjunction with a color standard that has been mutually agreed upon with a customer prior to production.

Titanium is one member of a family of metals (that includes niobium and tantalum) that color anodizes because it is “reactive"; i.e., it reacts when excited by heat or electricity in an electrolyte by creating a thin oxide layer at the surface. The oxide layer presents itself *in color* due to an *interference phenomenon*. This layer is a very thin, transparent coating that derives its ‘color’ when white light reflects off the base metallic surface, only to be “interfered with" within the coating. Some frequencies of light waves escape and recombine with surface light to be either reinforced or cancelled out—producing the color we see.

Creating “Color"
As the coating thickness increases, different frequencies escape, creating a variety of colors. The colors produced appear in up to five repeating orders. Not all the colors of the light spectrum are produced. Neither “true red" nor “forest green" are generated. Color anodized coatings are super thin (in the range of 200 to 3000 Angstroms) and, although they are harder than the titanium parts themselves, they do not exhibit excellent abrasion resistance characteristics because of the thinness of the oxide film.

The voltage being applied to the part(s) through an electrolytic bath controls the color. The coating may be created using various electrolytes, where the parts are made positive (anodic), with a corresponding negative (cathodic) terminal attached to a D.C. power supply. Processes are available that can “selectively" anodize surfaces to meet a particular customer’s requirements.

Color “Standards"
Understandably, it is important to a customer that every part be the same color within a lot, regardless of whether that lot quantity is 5, 50 or 5,000. Uniformity of color is achieved by developing process parameters and implementing controls that permit strict adherence to an established color standard. It is important to understand that the metal itself does not change color—there are no dyes or pigments as are found in aluminum anodizing. Rather, the thin, transparent oxide layer generates the “interference" colors. Because of the absence of dyes and pigments, anodized titanium implants are both hypoallergenic and biocompatible.

Within the medical device industry, products are color anodized primarily for cosmetic and/or identification purposes. In the Operating Room, for example, the O.R. staff might desire to have magenta, blue, gold, green and bronze “colors" that can help visibly differentiate various lengths of screws that possess the same diameter.

In summary, one may ask the question..."Why Anodize?"

Advantages/Features of Titanium Anodizing

Type 2 Anodizing
- up to 20% increase in fatigue strength
- anti-galling/increased lubricity
- biocompatible
- no dimensional change
- improved surface finish
- visual differentiation from stainless steel

Color Anodizing
- provides identification feature
- cosmetically appealing
- biocompatible
- some increased lubricity
- no dimensional change
- variety of colors available

Combinations of Type 2 and color anodizing treatments can be applied to the same component. By using masking and/or selective anodizing techniques, these surface treatments not only add beneficial performance characteristics, but they also provide a unique ‘look’ while concurrently incorporating distinctive identification, orientation, or design considerations and features.

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ALUMINUM AND TITANIUM FINISHING AND ANODIZING FOR PROTECTION, WEAR AND APPEARANCE

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