Navy Brings Advanced Technology to the Anodizing Process

Advanced Process Control Reduces Rejects and Defects in Finished Parts

Process engineers at the Naval Air Depot (NADEP) Jacksonville, FL are employing a new technology to enhance the quality of corrosion- and wear-resistant coatings applied to aircraft component parts. And there's a lasting benefit to the environment:

- By reducing the number of defects and increasing production efficiency, less energy and smaller amounts of chemicals are required to process component parts.
- Due to the precision control of the new technology, chemicals and energy are used more efficiently.
- A chemical additive reduces the amount of dissolved aluminum and the build up other contaminants in the bath during processing. Less dumping of the bath is required saving on waste disposal and the addition of fresh chemicals.

Background

For years, personnel from across the Navy have applied a variety of coatings to preserve, repair and maintain the integrity and performance of component parts. Anodizing is one such process for applying a coating that is extremely durable, abrasion and corrosion resistant.

Anodizing (formally know as "Anodic Coatings for Aluminum and Aluminum Alloys" under military specification (mil-spec) MIL-A-8625F) is an electrochemical oxidation treatment commonly formed on the surface of aluminum. It is produced by making the aluminum part positively charged using direct current while immersed in an electrolyte typically sulfuric acid. Oxygen ions within the electrolyte move towards the anode (i.e., the positively charged part) and combine with aluminum ions to form a layer of aluminum oxide known as the anodic or anodized coating. Because of its porous nature, the coating can also be dyed to a variety of colors and/or later sealed to further increase its corrosion resistant properties.

Personnel from NADEP Jacksonville have been producing anodic coatings on aluminum substrates using traditional methods for many years. These methods include manual operation/adjustments of the rectifier

Metalast™ Interface Controller shown underneath existing Rectifier Control Panel which monitors and controls system power outputs.

"I have always been an advocate for process control and cutting edge technology. I believe the Metalast™ Process Controller is a step in the right direction."

—Ruben Prado, Materials Engineering Laboratory, Jacksonville, FL

At the Surface Finishing Shop, Ruben Prado enters a "strategy" into the Metalast™ Integrated Process Controller prior to anodizing an EA-6B main landing gear.

(power source) to supply the required current to the work piece, the use of lead cathodes and copper buss bars. Though traditional anodizing has been used successfully, it has its share of disadvantages.

Ruben Prado, a process control chemist and surface finishing expert at NADEP Jacksonville's Materials Engineering Laboratory, explains, "Anodizing by manually controlling the voltage not only introduces inconsistent and non-reproducible results, but increases the risk of defects and rejects. This becomes a problem when anodizing alloys rich in copper since these alloys are more prone to "burning". Therefore, extra attention to accurately control current densities and ramp up rates is needed when anodizing these difficult alloys."

Anodizing by voltage control, particularly when controlled manually, is more sensitive to operating parameters including bath chemistry, temperature, the alloy being anodized, the method by which the parts are racked and the size of load. Variations in thickness in the resultant coating are significantly increased when processing parts by voltage. This creates a problem when a desired thickness is required per engineering specifications or when trying to achieve consistent and/or reproducible results.

Other considerations are the use of lead cathodes. Using aluminum cathodes considerably reduces the energy requirements thereby minimizing the amount of voltage required for anodizing. Typically a one to two voltage drop can be seen when converting to aluminum cathodes resulting in substantial energy savings. Additionally, replacing copper electrical conductors (busbars) with aluminum is beneficial because it minimizes sources of unwanted copper contamination in the bath. (It is important that only 6063-T5 or T6 aluminum alloy be used. Other alloys can dissolve readily in the bath.)

Transition to a New Technology

In April 2003, NADEP Jacksonville elevated their anodizing method to a new level of science and automation by taking advantage of current technologies while increasing quality and lowering costs. This was made possible by the use of the Metalast™ technology, developed by Metalast International, Inc. The technology consists of an Integrated Process Controller (IPC), an Interface Controller (IC), and a chemical additive for the bath chemistry.

The Process Controller

The Integrated Process Controller (IPC Pro Series) is an affordable process controller specifically designed for plating and anodizing processes. Installation and integration of the Metalast™ system (including an IPC Pro Series, Interface Controller (IC) with optional bath temperature monitor and

LEFT: Tom Adams shown anodizing an EA-6B main landing gear in modified anodizing tank.

BELOW: The Metalast™ Integrated Process Controller (IPC).

remote printer) went smoothly at a cost of under $30,000. The system has the ability to automatically regulate and control rectifier voltage and current, process ramping, stepping and timing, thus ensuring that superior quality control of coating consistency, durability, corrosion protection and appearance is precisely maintained per the requirements of the specification. Prado says, "I have always been an advocate for process control and cutting edge technology. I believe the Metalast™ Process Controller is a step in the right direction."

With minimal training, strategies (i.e. a set of Steps, Ramps and Plateaus) can be entered via a touch screen into the IPC and set up to run in either Automatic Voltage Control (AVC) or Automatic Current Control (ACC) mode. Fifty strategies (upgradeable to as many as 200) can then be stored for later use.

Once the process has been set up and started, the artisan no longer needs to constantly monitor the process. Previously, the artisan would spend 10 to 15 minutes per run manually ramping, monitoring and making adjustments to the rectifier. Now artisans can spend this time more effectively—preparing for the next anodizing run, inspecting parts or monitoring other critical aspects of the process.

Tom Adams, a shop artisan, says "the controller frees me up to work on other parts, since I know longer have to stand in front of the rectifier manually making adjustments." Once the process is complete, the controller signals an audible/visual alarm alerting the artisan of the completed cycle. A report with basic process time, alloy, date, current or voltage, among other information, is automatically printed at the end of each cycle run providing greater quality control and process verification. Other features of the controller include monitoring of the bath temperature, ampere hour meter, operator identification and interfacing with other equipment such as overhead hoists, chemical monitoring systems, and other materials handling systems.

The Interface Controller

The IC is basically the link between the process controller and system rectifier. It is what interfaces the Metalast™ IPC to the existing or new rectifier. The IPC communicates with the IC via a control area network and is connected by a single shielded cable. To minimize the effects of radiated interference, the IC is mounted as close as possible to the system rectifier. The IC continuously monitors voltage and current outputs from the rectifier and essentially takes control over the rectifier.

The Chemistry

The Metalast™ IPC alone is an excellent tool, but when used together with the optional bath additive, the system is complete. By incorporating control of the bath chemistry and all operation system parameters together with use of

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Benefits of
AN ENHANCED ANODIZING PROCESS

1. **Increased Reliability through Improved Corrosion Resistance**

   Corrosion resistance is typically measured using a salt spray procedure (ASTM B117) where the anodized samples are exposed to heated salt spray environments to accelerate corrosion. In order to pass MIL-A-8625F, Type II anodized samples must last 336 hours in the salt spray chamber before significant corrosion occurs. Anodizing using the Metalast™ technology has been demonstrated to withstand more than 4,000 hours of salt spray prior to failure greatly exceeding mil-spec requirements.

2. **Increased Reliability through Improved Accuracy/ Consistency of Desired Oxide Thickness**

   The Metalast™ controller accurately controls the anodizing process to approach the desired coating thickness. Consistency and accuracy of thickness of coatings accomplished with the controller has been shown to exceed the requirements of the mil-spec. (The mil-spec states that the thickness of the coating shall not vary by more than ± 20 percent for coatings up to 2 millimeters thick.)

3. **Reduced Costs Through Reduced Operator Supervision**

   The Metalast™ Process Controller operates with minimal operator supervision or intervention. Once the process is set up, the operator is released from having to constantly monitor the operation. This allows for the artisan to do other things like setting up for the next process run or inspect other areas of the process line.

4. **Increased Reliability Through Improved Repeatability of Process**

   The process controller is designed to provide repeatability by producing the same voltage/time and current/time regardless of the artisan running the process. Though there are other environmental factors the may affect the final coating (bath temperatures, concentrations, pre and post treatments, etc.) the controller accurately and consistently governs the amount of current needed to form the oxide, thus producing consistent and repeatable coating thickness.

5. **Increased Reliability Through the Elimination of Human Error/Reduction of Defects and Rejects**

   Many defects are caused by improper control of current during anodizing. With computer process control defects and rejects are reduced since accurately delivered currents and ramp up rates are achieved without introducing human error or variability from artisan to artisan. Again, as mentioned above, the accuracy and repeatability of the coating thickness is greatly enhanced.

6. **Improved Material Management Resulting In Environmental Benefits**

   Because the Metalast™ process controller works more efficiently than traditional methods, rejects and defects are reduced thus reducing the amount of energy and chemicals used for reprocessing of parts. Chemicals and energy are used more efficiently with the Metalast™ technology. Also, the Metalast™ anodizing technology significantly decreases the dumping frequency of tanks due to the high current density used in the Metalast™ anodizing technology and prevention of burning provided by the Metalast™ bath additive.

How Pervasive Is the Anodizing Process Across NAVAIR?

References to MIL-A-8625F in General and Type/Model Series Manuals

NADEP Jacksonville has initiated enhancements to its anodizing process by instituting the Metalast™ technology. How large is the potential benefit of similar improvements to the anodizing process elsewhere in NAVAIR? More specifically, how extensive is the anodizing process across the Naval Air Systems Command (NAVAIR)?

To obtain some idea of the pervasiveness of the anodizing process, an electronic search of references to MIL-A-8625F was conducted on over 9,800 naval aviation maintenance manuals using the Hazardous Material Authorized Use List (HMAUL) Analysis Tool (HAT). NAVAIR has approximately 20,500 active maintenance manuals. Inclusion rates in the HAT vary by program and are rising rapidly.

The results of the HAT search for MIL-A-8625F show that of the manuals included in HAT, 34 programs, 290 manuals, and 1,244 pages in the manuals reference the anodizing process. The analysis provides both the maintenance directives requiring the use of MIL-A-8625F and opportunities to further investigate enhancements of the anodizing process, similar to those initiated at NADEP Jacksonville, across multiple NAVAIR platforms.

(For additional information about the HAT, contact Eric Rasmussen at 732-323-7481 or eric.rasmussen@navy.mil. For additional information about NAVAIR's maintenance manuals, contact Ebbie Crockett at 619-545-2010 or elizabeth.crockett@navy.mil.)

Anodizing Across the Fleet: References in General and Type/Model Series Manuals

Program or Product Line	Manuals that Reference MIL-A-8625F	Pages that Reference MIL-A-8625F
H53	67	631
H60	53	180
FA18ABCD	29	70
H1	20	32
H46	14	28
S3	13	35
Accessories	12	46
General Series	10	15
C2	8	57
P3	8	50
AV8B	8	22
EA6B	7	9
Aircraft Launch and Recovery Equipment (ALRE)	6	8
E2C	5	6
F14	3	4
FA18EF	2	6
E6	2	6
F110	2	4
F404	2	4
H3	2	4
Shop Test Equipment	2	4
Common Support Equipment (CSE)	2	3
Electronics	2	3
T62	1	4
Guns	1	2
Instruments	1	2
Mobile Equipment	1	2
Air Combat Electronics (ACE)	1	1
Engines	1	1
Missiles	1	1
Survival	1	1
T2	1	1
T64	1	1
Targets	1	1
34 programs	290 manuals	1,244 pages

The existing anodize tank was upgraded to include 6063-T6 aluminum cathodes and busbars prior to installation of the Metalast™ Controller.

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its computerized Process Control System, finishes can be custom tailored to enhance certain performance characteristics, such as paint adhesion, corrosion resistance, wear or hardness in nearly half the time of traditional methods. The proprietary bath additive plays a major role in the quality and uniformity of the coating produced. The bath additive reduces or inhibits the dissolution of the oxide during anodizing thus preventing the negative affects of "burning". Because of the nature in which the additive works, higher current densities may be used thus allowing for shorter run times and increasing throughput. Also, since burning is reduced, aluminum dissolution and the build up of aluminum ions are reduced minimizing the amount of dumping required.

Benefits

After making the modifications to one of NADEP Jacksonville's existing anodize lines, the benefits of the new technology were soon recognized. The engineering benefits of the Metalast™ System include:

- Increased process consistency, throughput and verification,
- Can be used with most electrochemical processes,
- Improved accuracy and repeatability of the process,
- Reduced defects and rejects in finished parts,
- Overall increase in efficiency and quality of coating,
- Lower labor and energy costs,
- Affordable and user friendly technology with minimal training required, and
- Facilitates compliance with read International Organization for Standardization (ISO) and quality standards.

In addition, the new system results in important environmental benefits, including:

- Less energy and smaller amounts of chemicals are required to process component parts due to reductions in the number of defects and increasing production efficiency.
- Chemicals and energy are used more efficiently due to the precision control of the new technology.
- Reductions in the amount of dissolved aluminum and build up other contaminants in the bath during processing due to the introduction of a chemical additive used with the new technology. Less dumping of the bath is required saving on waste disposal and the addition of fresh chemicals.
- Allows for combining both Type II and Type III processes into one process tank. This saves on the chemicals used.

Anodizing using the Metalast™ Process Controller was successfully demonstrated on an EA-6B Main Landing Gear, enabling production to produce a superior coating with less risk of damaging defects. Prado stated, "It was a first for us not only to anodize a difficult part like the EA-6B landing gear, but to use this technology as well. I was very pleased to see how uniform the coating was and how well the system worked." NADEP Jacksonville's goal is to ultimately make Metalast™ the new standard for anodizing of aluminum alloys within Depot level maintenance. ⚓

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