Improved Process Capabilities for Groove Repair

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Who We Are

• SIFCO Applied Surface Concepts
  • Founded in 1959
  • Headquartered in Cleveland, Ohio, USA
  • Acquired as part of the Surface Coatings Division of Norman Hay in 2012.
  • 4 US and 3 European Locations
    • USA:  Ohio, Texas, Connecticut, & Virginia
    • Europe: UK, France, & Sweden

• Norman Hay Group
  • Founded in 1940 doing Chromium Plating and Hard Anodizing
  • Headquartered in Coventry, UK
  • Ultraseal International, Surface Technology, and NHE
Overview

• What is Selective Plating (AKA Brush Plating)
• Specifications
• What is a groove?
  • Groove configurations
• Groove Plating Advancements
  • Case Studies
  • Challenges
• Conclusion/Future Work
What is Selective Plating/Brush Plating?

- The SIFCO Process® is a portable method of electroplating localized areas without the use of an immersion tank.

Key Requirements:

1. Workpiece
2. Power Pack
3. Plating Tools
4. Solution

Other:

- Solution Flow System
- Masking Materials
- Auxiliary Equipment
Selective Plating/Brush Plating

Surface Preparation
- Pre-Clean
- Electroclean
- Etch
- Desmutting
- Activation
- Preplate
- Plate
Selective Plating/Brush Plating Features

- Higher current density plating because of:
  - Higher metal concentrations
  - High solution velocity replenishment of metal ions at the surface
  - Brushing action disturbs the hydrodynamic boundary layer at the surface resulting in faster solution movement.
  - Hydrogen gas bubbles are removed by the brushing action and high solution velocity.

- Brushing action levels the deposit as it builds.

- Selective plating allows for easily controllable application of the coating just where it is needed on the part / component
## Selective Plating Specifications

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<tr>
<th>FINISHES</th>
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*Tank plating standard. SIFCO ASC does not perform tank plating, but manufactures many deposits that meet the performance requirements of the standard.

- **MIL-STD-2197**
- **MIL-STD 865C**
- **AMS 2451C**

### Commercial Specifications (Partial List)

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Types of Grooves

- O-ring grooves
- Packing grooves
- Snap ring grooves
- Retaining ring grooves
- Fluid control
- Keyways
- Splines
- Threads
- Gears
Groove Plating Objectives

In an *ideal world*…

• Uniform deposit along all surfaces
• No post machining

The Challenge…

• Maximize plating into internal corners
• Minimize build-up at high current density edges
• Can require multiple applications

Requires OPTIMIZED plating parameters!
The Advancements....

Brush Plating

Traditional Brush Plating
- High Current Density
- Non-uniform plating distribution
- Limited plating along internal radii
- Dendritic along external edges

Selective Areas
- Reduced CD Anode Masking
- Less build-up along external edges
- Increased deposit throw along internal radii

Wrap-Less Plating

Reduced CD
- Selective Masking
- Minimal build-up along external edges
- 3x more deposit throw along internal radii
- Improved deposit uniformity

Tight Tolerance Tooling
- Reduced CD Selective Masking
Traditional Selective Plating/Brush Plating

- Poor efficiency and time consuming
- Poor thickness distribution
- Limited throwing power along radial areas
- Excessive deposit build-up along external edges
Case 1: Traditional Brush Plating

- Deposit: AeroNikl 250
- OD Groove
  - Diameter 6 inch
  - Groove Dimensions: 1/2 in x 3/16 in
- Plating Parameters
  - CD: 3-6 ASI
  - Thickness: 5.5 mils (18 AH)
  - Anode: Ni Tube with PTW
- Results
  - Could not maintain constant current
  - Low thickness
  - Excessive build-up of dendritic deposit along top corners
  - Numerous overloads and arcing during plating
  - Not reliable or repeatable
Case 1: Wrap-Less Groove Plating

➢ Deposit: AeroNikl 250

➢ OD Groove
  • Diameter 6 inch
  • Groove Dimensions: 1/2 in x 3/16 in

➢ Plating Parameters
  • Thickness: 5.5 mils (18 AH)
  • CD: <1 ASI
  • Anode: Ni Tube NO Wrap
  • Selectively masked anode

➢ Results
  • Constant current maintained
  • Thickness: 8 mils after 8 AH of plating
  • Deposit build-up along external edges reduced
  • Good coverage along the internal radial areas
Case 1: Wrap-Less Groove Plating

Cross Section at 500x magnification

- Groove Bottom Max Thickness at Center: ~8 mils
- Internal Radius Thickness: ~1 mils
- External Corner Thickness: ~15 mils
- Throw Power into radius: ~10-12%
Case 2: Brush Plating Selective Areas

- Deposit: AeroNikl 575

- Groove Dimensions
  - Groove Width: ~1/4 inch
  - Groove Depth: 3/16 – 1/3 inches
  - Groove walls selectively plated

- Plating Parameters
  - Thickness: 5 - 13 mils
  - CD: 3 ASI
  - Anode: Dur-A-Form with RTW
  - Anodes selectively masked

- Equipment Configuration
  - App. 1: Stationary part with moving anode
  - App 2: Stationary anode with rotating part
Case 2: Brush Plating Selective Areas – Anode Masking
Case 2: Brush Plating Selective Areas

Results
- Plated to size, required no post machining
- Deposit is thicker at the bottom of the groove compared to the top of the groove
Case 3: Wrap-Less Groove Plating

- Deposit: AeroNikl 250
- ID Groove
  - Diameter: 4.5 inch
  - Groove Dimensions: 9/32 x 5/32 in.
- Plating Parameters
  - Thickness: 5 – 30 mils
  - CD: <1 ASI
  - Anode: Wrap-less Dur-A-Form
    - Selectively masked anodes
  - Tight Tolerance Tooling:
    - Defined anode to cathode gaps
  - Equipment Configuration
    - Stationary part with rotating anodes
Case 3: Automated ID Plating, Rectifier Software & Data Logging

HMI/Software & Rectifier
Case 3: Wrap-Less Groove Plating

Anode Fins seated in Grooves.
Solution flowed through anode.

Masked Mock-up Grooves
Masked Anode Sides
Case 3: Wrap-Less Groove Plating

- **Parameters Tested**
  - Anode to Cathode Gap
    - 0.0050 vs 0.075 inch
  - Current Densities
    - 0.5, 1 ASI, and 3 ASI
  - RPM

- **Increasing CD and Anode to Cathode Gaps...**
  - Diminished throw power 10-15%
  - Thickness variation from side to side
  - Rougher deposit
Case 3: Wrap-Less Groove Plating

- Lower current densities and decreasing anode to cathode gaps …
  - Increased deposit throw power along internal radii by 3x
  - Reduced thickness variation from side to side
  - Smoother deposits allow for thicker deposits
  - Decreased deposit build-up along external edges
Wrap-Less Groove Plating – Data Logging

Constant Current

Increasing voltage variation

Voltage
Wrap-Less Groove Plating
Conclusion & Future Work

Groove Considerations

• Groove Geometry
  - Location, depth, width
• Deposit Types & Specification Requirements
  - Deposit choice
  - Wear/Corrosion/Dimensional Restoration
  - Internal radius requirements, taper allowance, uniformity
  - Design modifications for chamfers and larger radii
• Post Finishing
  - Surface roughness
  - Machining

Plating Process Considerations

• Current Density
• Selective Masking
• Anode-to-Cathode Gap
• Anode & Fixture Design

Future Work/Considerations

• Continue to increase throw power into the corners
• Minimize machining in between applications
  - Pulse Plating
  - Additives
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QUESTIONS?

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See us at Booth 330!
Brush Plating Small Features

➢ Deposit: Nickel 2080 on Al

➢ Groove Details
  • U-Channel & Dovetail
  • Groove Dimensions: 1/8 x 1/8 in.

➢ Plating Parameters
  • Thickness: 0.2 – 0.7 mils
  • CD: < 1 ASI
  • Two-step plating process
  • Anode selectively masked
  • Equipment Configuration
    - Rotating part with stationary anode
Brush Plating Small Features (U-Channel)

- Face ~0.4 mil
- Groove Corner ~1mil
- Bottom of Groove ~0.6 mil
- Groove Radius ~0.11 mil