ABSTRACT
ASRM PROCESS DEVELOPMENT IN AQUEOUS CLEANING

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Process development in aqueous cleaning is taking place at the Aerojet Advanced Solid Rocket Motor (ASRM) Division under a NASA Marshall Space and Flight Center contract for design, development, test and evaluation of the ASRM including new production facilities. Lockheed Missiles and Space Company and Aerojet have formed a team partnership. Lockheed, as prime contractor, is providing systems engineering and integration and facility construction with overall responsibility and accountability for the project. Aerojet, as a subcontractor, is heading the propulsion design, development, and manufacturing of the new booster. The ASRM will utilize aqueous cleaning in several manufacturing process steps to clean case segments, nozzle metal components, and igniter closures. ASRM manufacturing process development is underway, including agent selection, agent characterization, subscale process optimization, bonding verification, and scale-up validation.

After a literature search and screening demonstrations of 11 aqueous cleaning agents, three agents (Turco 3878 LF-NC, Daraclean 283, and Blue Gold) were chosen for cleaning ability demonstrations. As a result, Turco 3878 LF-NC has been selected for further process testing. Process parameters are currently being tested for optimization utilizing a Taguchi Matrix, including agent concentration, cleaning solution temperature, agitation and immersion time, rinse water amount and temperature, and use/non-use of drying air.

Based on results of process development testing to date, several observations are offered:

- Aqueous cleaning appears effective for steels and SermeTel-coated metals in ASRM processing.
- Aqueous cleaning agents may stain and/or attack bare aluminum metals to various extents. Effects have not been characterized.
- Aqueous cleaning appears unsuitable for thermal sprayed aluminum-coated steel.
- Aqueous cleaning appears to adequately remove a wide range of contaminants from flat metal surfaces, but supplementary assistance may be needed to remove clumps of tenacious contaminants embedded in holes, etc.
- Hot rinse water appears to be beneficial to aid in drying of bare steel and retarding oxidation rate.

In summary, process development in aqueous cleaning for the ASRM Project is progressing satisfactorily. An agent has been selected and subscale process optimization is in progress. Aqueous cleaning has been demonstrated at the lab scale to be an effective alternative to vapor degreasing. The Aerojet ASRM Division and the entire ASRM Team are committed to successful activation of full-scale aqueous cleaning processes.
ASRM Process Development
In Aqueous Cleaning

December 8, 1992

Bill Swisher
Process Optimization
Cleaning Agent Selection
Purpose and Logic

Overview
- HP9N1-4C0-0.3C Steel
- Igniter Closure
- Coating Serrinet 1207/1208
- 7050/7075 Aluminum
- Coatings TSA OR Serrinet 64-1
- D6AC Steel
- Nozzle
- HP9N1-4C0-0.3C Steel
- Case Segments

ASRM Aqueous Cleaning

Purpose And Logic
ASRM Manufacturing Process Development Specification TM0528

Development Testing Logic

Purpose and Logic
Goal To Select Three Agents For Further Testing:
- Steel - Chernock - EPM Insulation
- Bond In Tension Comparison
- Storage In Nitrogen
- Cleanliness And Compatibility Comparison
- Corrosion 419
- Humisate Heavy Duty
- Humisate Special
- Gellite 0650
- Duraclean 222
- Turco 4215
- Turco 6778
- Turco 6778 LF-NC
- Duraclean 815 Ged
- Eleven Candidates Tested For Corrosion And Bonding Effects With DAC 9 and HPG-4-30 Steel

Task 1 - Screening Demonstration Test

Agent Selection
Space Vehicle Division
- Emulsion Cleaning History By Martin Marreta
  - Blue Gold (Modern Chemical Co.)
  - History Cleaning Small Parts In Industry
  - Darclean 283 (W.R. Grace Co.)
  - Propulsion Division
- Emulsion Cleaning History By Aeroljet
  - Turco 3878 LF-NC (Turco, Inc.)

Three Agents Selected
- Bond Strength Similar
- None Caused Lowered CONSCAN Readings
- No Adverse Corrosion or Compatibility Reactions
- Above Others

No Candidate Agent Performed Definitively

Results

Task 1 - Screening Demonstration Test (Cont'd)
- Bonding Demonstration (HPg-4.30)
- Cleaning Ability Demonstration (All)
- Compatibility Characterization of Coated Materials
- Residual Species Analysis (HPg-4.30)

Data Collected:

- 7075-T73 Aluminum
- HPg-4.30, TSA 4130 Steel, and Sermel
- Several Basis Metals Tested

Three Agents Tested For Down Selection

Task 2A - Cleaning Ability Test
Media Blast
Provided Cleaner Base Metal Surface Than
All Three Removed Particulate And

1. Blue Cold 0.0
2. Dacclean 283 6
3. Turco 3878 LF-NC 3
4. No Agent (Control) 5
5. Agent Particulate NVR

Results:
Remain On Cleaned Metal Surface
Purpose: To Demonstrate If Residual Species

Residual Species Analyses

Task 2A - Cleaning Ability Test (Contd)
Compatibiltiy Characterization

Task 2A - Cleaning Ability Test (Contd)

- Purpose: To Demonstrate Effect Of Cleaning Solutions On Nozzle Metals

- Results:
  - Turco 3878 - No Foaming
  - LF-NC - Mild Staining Of Surface
  - Least Rust Color Under Surface Coat
  - TSA Steel
  - Sermetel Aluminum
  - Aluminum

- Daraclean 283 - Heavy Staining Of Surface
  - Most Rust Color Under Surface Coat
  - Blue Gold - Moderate Foaming
  - Moderate Staining Of Surface
  - Rust Color Under Surface Coat
  - No Reaction

- No Reaction

- Lightly Tarnished (Blackened)

- Moderately Tarnished

- Heavily Tarnished
Steel to develop corrosion
and rinse water which over time caused underlying surface discoloration and apparent coating loss.

- TSA coatings were adversely affected.
- Light to heavy cupping caused by agents.
- Bare aluminum requires more testing (Turco Best).
- Agents compatible with semimetal coating.

Compatibility Characterization

Results of Task 2A - Cleaning Ability Test (Cont'd)
Cleaning Ability Demonstration

Task 2A - Cleaning Ability Test (Cont'd)
Removed by any agents

- Clumps of grease in panel holes were not

Blue Gold Failed

(except TSA coated steel)

Turco and Daraclean Removed Surface Grease

Blue Gold Less Vigorously

Three agents continued cleaning 30 minutes

Cleaning Ability Demonstration

Results

Task 2A - Cleaning Ability Test (cont'd)
Results:

- Test Data Summary:
  - Turco 3878 LF-NC: Slightly Higher Strength Than Others
  - All Samples Failed Cohesively In Insulation

Purpose: To demonstrate Bonding Strength

Bonding Demonstration

Task 2A - Cleaning Ability Test (cont'd)
List Of Contaminants:

Thermal Protection Residue
-EPM Rubber Residue
-Bug Residue
-Shop Dirt
-Road Dirt
-tyrocation Soot
-Touchor Slurry
-Bird Droppings
-Camwax (Tool Coating)
-Volatile Corrosion Inhibitor Residue
-Plastic Blast Media Residue
-Nyron Residue
-Zine Chromate Residue

Bugs Organic Residue
-Fingerprints
-Tinmol Cutting Fluid
-Shop Marker Grease Pencil
-Tolynezole
-Sodium Borate
-Sodium Nitrite
-Sodium Molybdate
-Corrosion Inhibitors:
-Hydraulic Fluid
-Conoco HD-2 Grease

Specification Bond Strength
Levels That Do Not Interact With
Success Criteria: To Remove Contaminants To

All Expected Potential Contaminants
Purpose: To Verify Turco 3878 LF-NC Able To Clean

Task 2B - Case Cleaning Ability

Agent Selection

Aerogel
AECorp
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<th>Compound</th>
<th>Degraded</th>
<th>Improved</th>
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<tr>
<td>HD-2 Grease</td>
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<tr>
<td>Teflon Slurry</td>
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<tr>
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<tr>
<td>Cor Inhibitors</td>
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<tr>
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<td>Hydraulic Fluid</td>
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<tr>
<td>Fingerprints</td>
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**Task 2B Results**

**Task 2B - Case Cleaning Ability (Cont'd)**
Task 2B Results (Cont'd)

- Small Bond Strength Variation
- Adequate Bond Strength Demonstrated For Turco 3878 LF-NC
- All Samples Failed Cohesively In Rubber
- All Contaminants Removed Sufficiently
- Chemlok Bonding Ability Must Be Factor

Nov 28 '92 9:13
Potential ASM Contaminants
Demonstrated Ability To Remove Wide Variety Of
Analysis
Co-Winner With Blue Gold In Residual Species
Cleaning Ability Demonstration
Co-Winner With Daraclean 283 In HD-2 Grease
Bonding Demonstration
- Compatibility Characterization Testing
- Best Results Over Other Two Agents In
Turco 3878 LF-NC Selected

Agent Selection
GenCorp
ASRM Division
Task 3 - Process Optimization

- **Purpose:** To Evaluate The Sensitivity Of The Aqueous Cleaning Process To Changes In Parameters That Control The Process

- **Taguchi Matrix Utilized**

- **Success Criteria:** Identify Preliminary Target Process Settings And Functional Limits (NVR Cleanliness Levels Must Also Be Within Level Previously Demonstrating Successful Bonding)

- **Bonding To Be Verified In Task 4 Utilizing Optimized Process Settings**

- **Task 3 Currently In Progress**
General Observations

- Aqueous Cleaning Appears Effective For Steel And Sermetel Coated Metal
- Aqueous Cleaning Appears Unsuitable For Thermal Spray Aluminum Coatings
- Aqueous Cleaning Appears To Remove Wide Variety Of Contaminants From Flat Surfaces, But Supplementary Assistance Needed To Remove Tenacious Contaminants From Holes
- Aqueous Cleaning Appears To Remove Wide Variety Of Contaminants From Flat Surfaces, But Supplementary Assistance Needed To Remove Tenacious Contaminants From Holes
- Hot Rinse Water Appears To Be Beneficial To Aid Drying To Prevent Oxidation Of Bare Steel
Full-Scale Facility Activation

We're Committed To Successful

is Effective Alternative To Vapor Degreasing

demonstrated at lab scale. That aqueous cleaning

- Optimization in Progress

- Agent selected

is progressing satisfactorily

ASRM Process Development in Aqueous Cleaning

Summary

ASRM Aqueous Cleaning Development