Environmentally Friendly Paint Removal from Military Components

WP18-D4-5031

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Final Debrief

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Implement environmentally friendly PEDP (Plasma Electrolytic De-Paint)/UADP (Ultrasonically Activated De-Paint) technologies for paint removal from military components
-Qualify the process for aluminum- and magnesium-based alloys
-Adapt process for use on a variety of DoD components
-Develop process documentation required for implementation

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- Dr. Natasha Voevodin - University of Dayton Research Institute
- Nora Tesone – University of Dayton Research Institute
- Robin Sutherland – University of Dayton Research Institute
- Dr. Solomon Berman - IBC Materials & Technologies, Inc.
- Dr. Gajanan Kulkarni - IBC Materials & Technologies, Inc.
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- Ashok Ramaswamy – IBC Materials & Technologies, Inc.

Technical Objectives

- Implement environmentally friendly PEDP (Plasma Electrolytic De-Paint)/ UADP (Ultrasonically Activated De-Paint) technologies for paint removal from military components
  - ♦ Qualify the process for aluminum- and magnesium-based alloys
  - ♦ Adapt process for use on a variety of DoD components
  - ♦ Develop process documentation required for implementation

Performance Objectives

Performance Objective	Data Requirements	Success Criteria	Success Criteria Achieved?
Quantitative Performance Objectives			
Qualify PEDP/UADP processes for coating removal on aluminum alloys	JTP requirements	Criteria set by JTP/ comparable to control (anodized only, no paint or de-paint process)	PEDP caused localized pitting to the surface of de-painted coupons due to copper inclusions in aluminum alloys*, did not pass corrosion and fatigue requirements (*de-painted specimens were not re-anodized for qualification testing) UADP met JTP qualification requirements** (**fatigue and tensile testing was not performed for UADP-processed specimens)

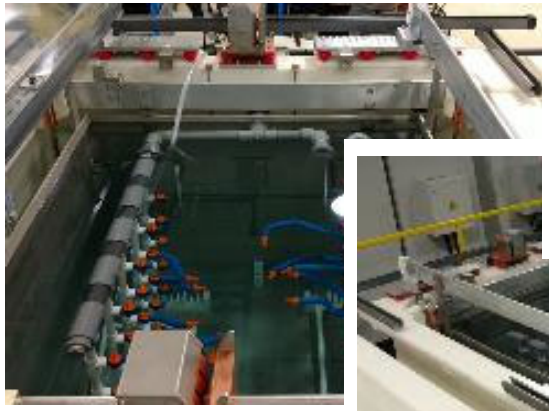
Performance Objectives

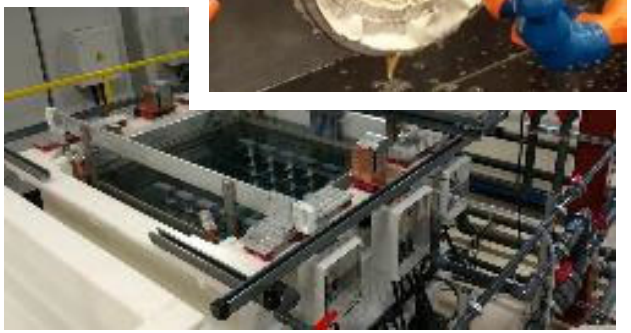
Performance Objective	Data Requirements	Success Criteria	Success Criteria Achieved?
Qualitative Performance Objectives			
Environmentally Friendly	Industrial Health Risk Assessment (PEDP) Emission Testing (UADP)	Eliminate the use of methylene chloride chemical stripper and PMB post processing in coating removal operations at DoD depots	Yes – PEDP and UADP are environmentally friendly, cost effective, non-line-of-sight processes for effective and efficient removal of paint from military components
Cost Effective	Cost Benefit Analysis	Be cost effective	

Demonstration Site

IBC Materials & Technologies, Inc (Lebanon, IN)

- Private Company, Founded 1996
- Located in Lebanon, IN near Indianapolis
- 100+ employees / 100K sq. ft facilities
- PEDP/UADP demonstration systems





Test Design

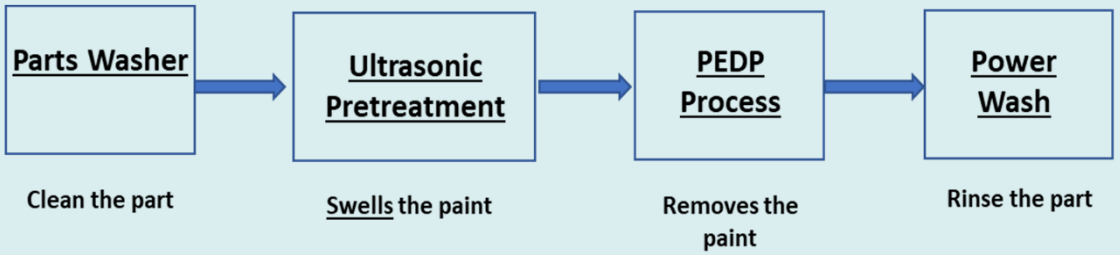
- Experimental Design Overview:
  - ♦ Process Parameters Optimization/ Coupon Scale De-paint
  - ♦ Qualification Testing IAW JTP
  - ♦ DoD Components De-paint Demonstration (PEDP/UADP)
  - ♦ Full Scale Aircraft Wheel De-paint Demonstration
  - ♦ Technical Package Development (UADP)
    - Emissions testing, cost assessment, installations requirements and procedures, safety analysis and requirements

Experimental Design Phases	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Process Parameters Optimizations/ Testing Coupons De-paint														
Qualification Testing IAW JTP														
DoD Components De-paint Demonstration (PEDP/UADP)														
Full Scale Aircraft Wheel De-Paint Demonstration (UADP)														
Technical Package Development														

Test Design

- Process Parameters Optimization:
  - To determine the set of parameters that result in the most efficient coating removal process providing acceptable finish

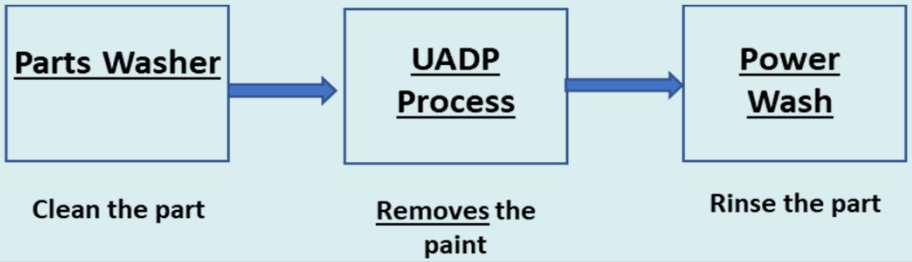
(1) Initial optimization of the PEDP process



(2) "New" process development for the PEDP process

- ❑ use of corrosion-preventing additives in PEDP electrolyte

(3) UADP Process development



Test Design

- Qualification Testing IAW JTP (PEDP/UADP)

Requirement	Data Requirements/ Test Methods	Acceptance Criteria
Appearance	Visual Inspection	No residual paint left on the surface, anodized layer is intact, no visible substrate damage
Surface Finish/ Surface Characterization/ Surface Chemical Composition	Microstructural Evaluation (cross-section, SEM, EDS) X-ray Florescence Spectroscopy	Surface characteristics comparable to control*; No damage to the underlying anodized layer/ or substrate
Mechanical Properties: Micro-hardness Tensile Fatigue	Micro-hardness (ASTM E92) Tensile (ASTM E8) Load-controlled fatigue (ASTM E466) Strain-controlled fatigue (ASTM E606)	Micro-hardness, Tensile: within 10% of control* Fatigue: greater than 80% of control* at 5 of the 6 levels
Paint Adhesion	FED-STD-141, Method 6301	No inter-coat separation between the paint system and the anodic coating or between the anodic coating and the base metal (per MIL-A-8625)
Corrosion (Salt Spray Resistance)	Salt Spray (ASTM B117, 336 hrs per MIL-A-8625)	No more than a total of 15 isolated pits, none larger than 0.031 inch in diameter, in a total of 150 $inch^2$ of test area grouped from five or more test pieces (per MIL-A-8625)
* control – anodized, not treated with PEDP/UADP		

Test Design

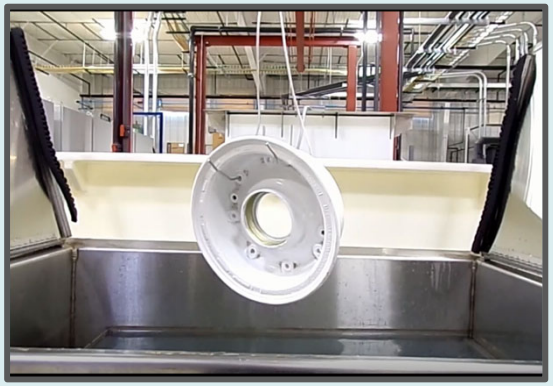
- DoD Candidates Components for De-Paint

DoD Service/ Part	Part/ Component	Coating Stack-up
UASF/ Brake Housing (Al2014-T651)		Al2014-T651 Sulfuric acid anodizing with sodium dichromate sealer per AMS 2471; MIL-PRF-23377 Type I Class N (Cr-free) primer; MIL-PRF-85285 Type I, Class H top coat
Navy/ Aircraft Wheel (Al7075-T73)		Al7075-T73 Sulfuric acid anodizing with sodium dichromate sealer per AMS 2471; MIL-PRF-85582 Type I Class C1 Cr-based primer MIL-PRF-85285 Type I, Class H top coat
Army/ Intermediate Gearbox (MgZE41A-T5)		MgZE41A-T5 Tagnite per MIL-DTL-32459 Type III/ RockHard Resin per MIL-PRF-3043; MIL-PRF-23377 Type I, Class C2 Cr-based primer; MIL-DTL-53039 (FED-STD-595 Color#36231) coating

Test Design

- Full Scale Aircraft Wheel De-paint Demonstration (UADP)

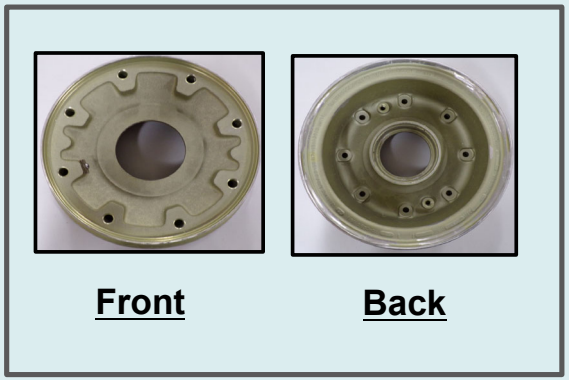
Set-up for suspending the wheel in the sonicator



Step 1: The wheel is ready to be dispensed in the sonicator

Step 2: De-painted wheel after sonication

Step 3: Low pressure (>500 psi) power wash (viewed through plexiglass)



Step 4: Fully de-painted wheel

Performance Assessment

- Qualification Testing Results Summary

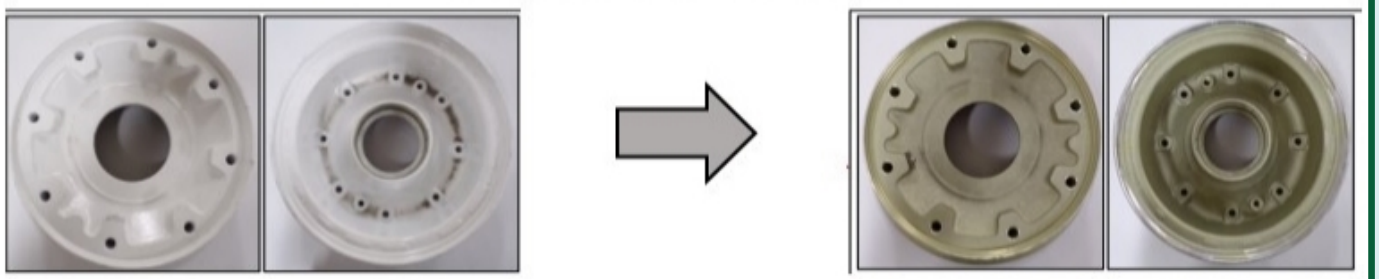
Performance Requirements	Results (Pass/Fail)			
	PEDP		UADP	
	Al 2014	Al 7075	Al 2014	Al 7075
Visual Inspection	Pass	Fail	Pass	Pass
Surface Finish	Fail	Fail	Pass	Pass
Microstructural Analysis	Fail	Pass	Pass	Pass
Surface Chemical Composition	Pass	Fail	Pass	Pass
Roughness	Pass	Pass	Pass	Pass
Tensile	Pass	Pass	N/A*	N/A*
Fatigue	Pass	Fail	N/A*	N/A*
Micro-hardness	Pass	Pass	Pass	Pass
Adhesion	Pass	Pass	Pass	Pass
Corrosion Resistance	Fail	Fail	Pass	Pass

*N/A – Tensile and Fatigue testing was not performed for UADP-processed coupons

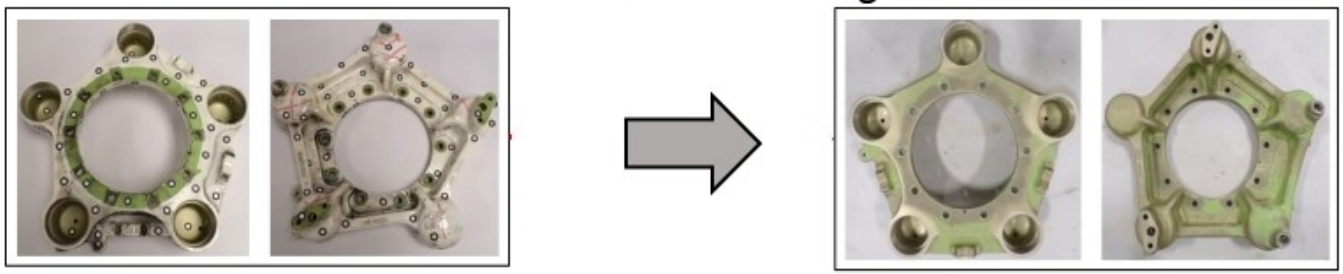
UADP De-Paint of Military Components

Paint peels off in 60 minutes in sheets

Aluminum Aircraft Wheel

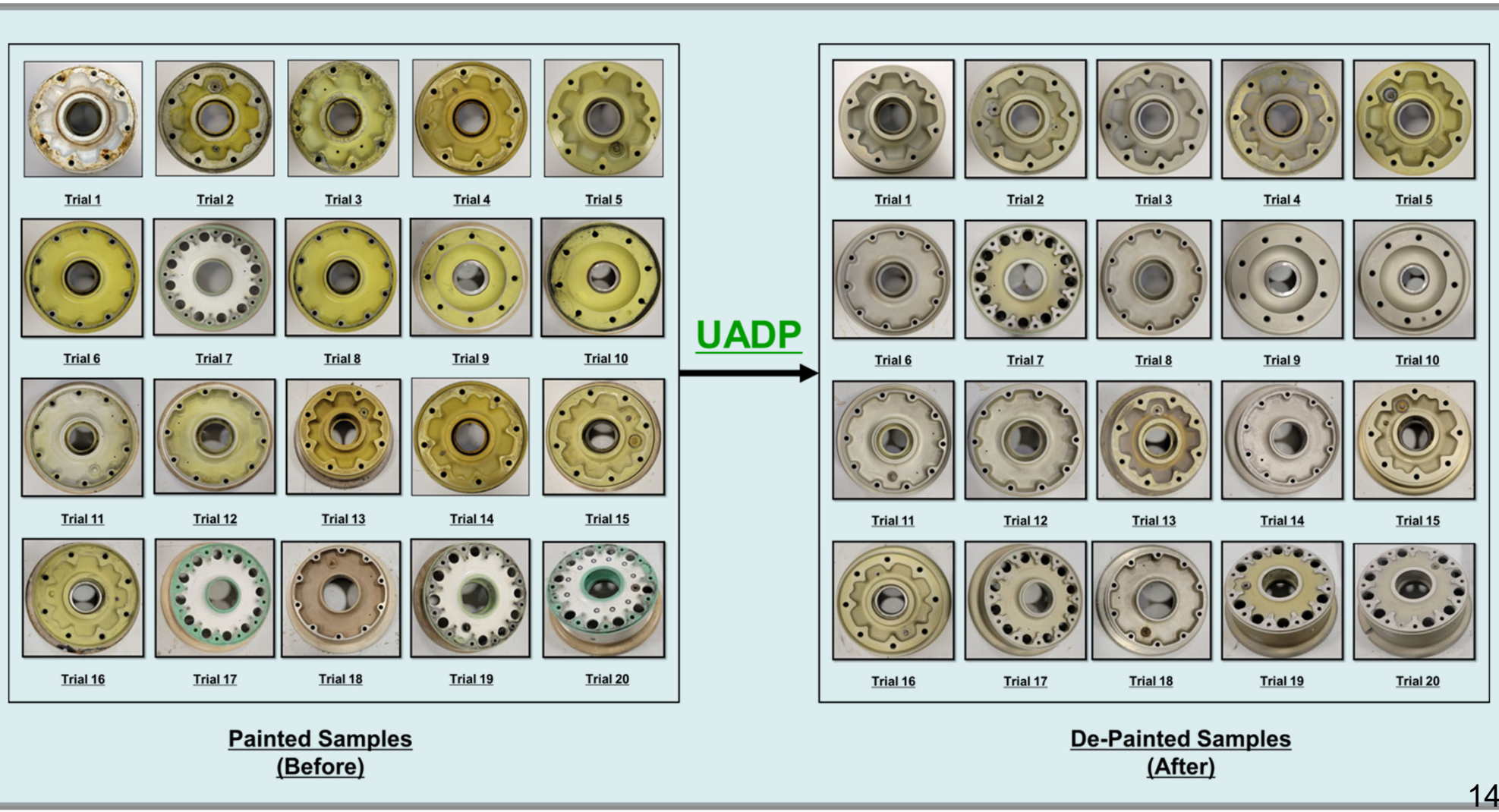


Aluminum Brake Housing

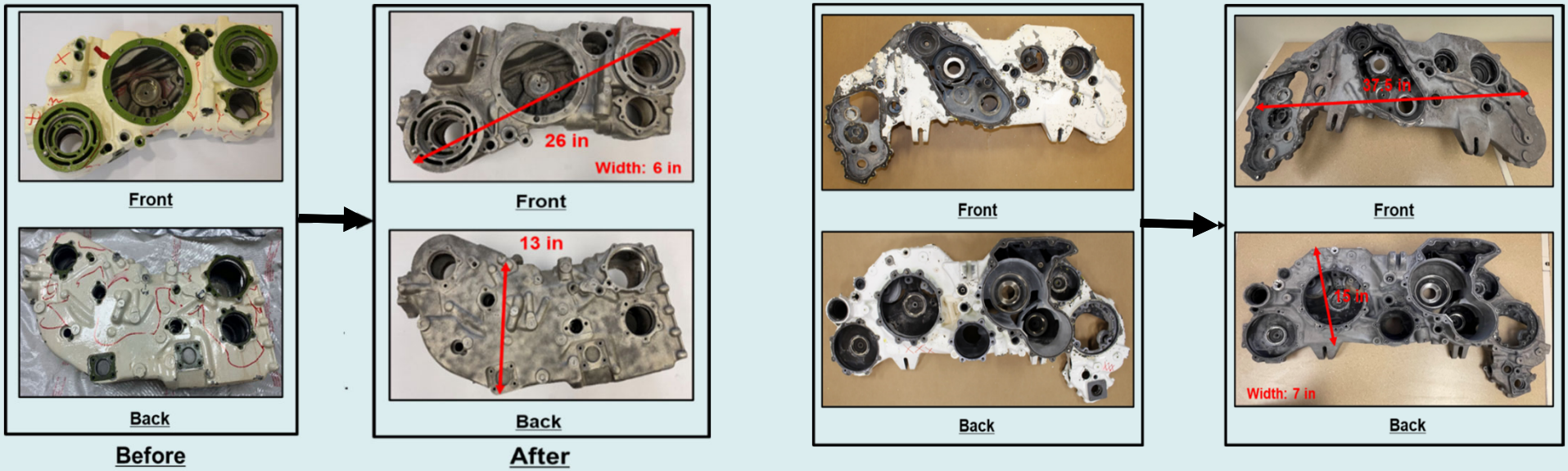


UADP Process on Aluminum Aircraft Wheels

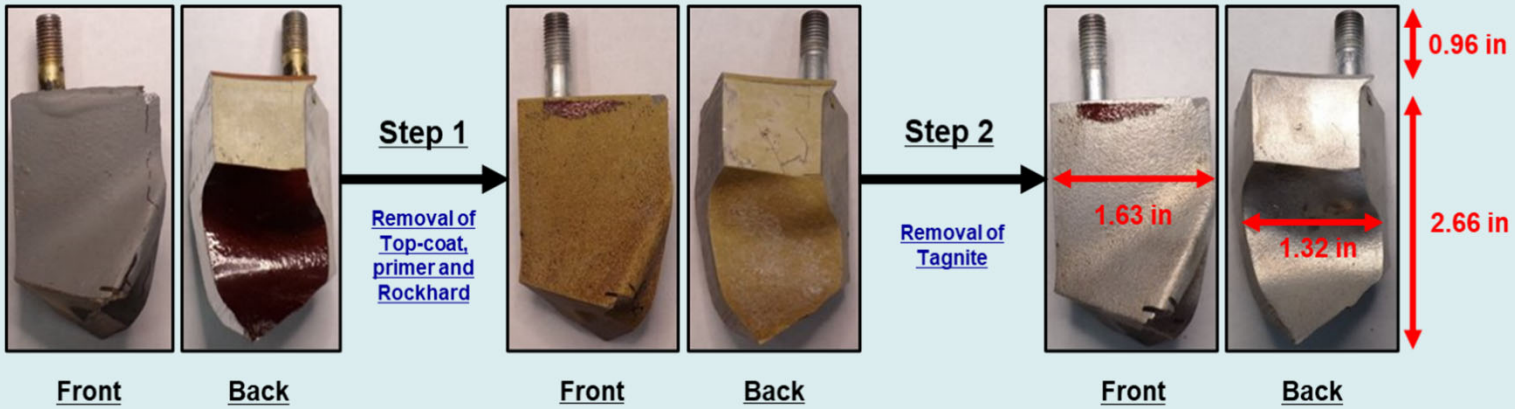
Repeatability Trials



UADP De-Paint of Mg Gearboxes



Paint Removal from USAF Gearboxes (with Alodine)



Two-step Paint Removal from Army Gearbox Sections (with Tagnite)

Emissions Testing for UADP

- Performed by KERAMIDA Inc, Indianapolis, IN
  - To assess potential personnel exposure to UADP bath solution during the test runs of paint removal in sonication bath
- Ultrasonicator Bath Solution
  - Environmentally friendly solution (currently proprietary information)
  - The solution was preheated over several hours prior to the testing, reaching a max temp of 75ºC
- Sampling
  - Approximately 4 feet from the edge of the tank and at breathing height (approximate location of the operator breathing zone in the area during a cycle)
  - Two area samples were collected for each analyte
    - Prior to the cycle and during cycle
  - A blank sample for each analyte was analyzed for QA/QC on the day of the sampling event

- Conclusions: Work area vicinity concentrations recorded in this study did not exceed the OSHA TWA PEL

TWA – Total Weigh Average
PEL – Permissible Exposure Limit

Results Summary for UADP Emission Testing

Sample-	Analyte	Recovered Concentration (ppm)	As 8 hr TWA (ppm)	OSHA PEL 8 hr TWA (ppm)
1st sampling (4/26/21)				
Pre-Cycle	Electrolyte	0.24	0.03	10
During Cycle		0.41	0.05	
Field Blank		N/A	N/A	
Pre-Cycle	Additive	<0.38	0.05	None listed
During Cycle		0.48	0.06	
Field Blank		N/A	N/A	
2nd sampling (4/27/21)				
Pre-Cycle	Electrolyte	0.18	0.02	10
During Cycle		0.32	0.14	
Field Blank		<0.010	N/A	
Pre-Cycle	Additive	0.38	0.05	None listed
During Cycle		0.36	0.15	
Field Blank		<0.010	N/A	

TWA – Total Weight Average
PEL – Permissible Exposure Limit

Scale-up

- UADP demonstration system at IBC
  - Aircraft wheels, gearboxes and bomb racks
- A system for large parts will require
  - Larger size tanks (sonication and rinse), custom automatic pressure wash system and more ultrasonic transducers
- The cost of UADP system for large parts will depend on
  - Tank sizes, transducers and custom pressure washer
  - Estimate: $1 M to $3 M range
- There is no anticipated limit to scalability of the UADP technology in terms of cost, efficacy or operational safety

Next Steps

- WP22-7328: Demonstration and Validation of an Ultrasonic Activated De-Paint Pilot Line at the Advanced Technology and Training Center (ATTC) near Robins AFB
  - Objective:
    - To eliminate use of methylene chloride ($MeCl_2$) and n-methyl-2-pyrrolidone (NMP) currently used to de-paint aircraft components during maintenance operations
    - To demonstrate and validate UADP pilot line at ATTC near Robins AFB
  - Tasks:
    - Develop/provide training
    - Design/fabricate tooling and fixtures
    - Perform testing and materials characterization
    - Demonstrate and validate the UADP pilot line on various DoD components

Technology Transfer

- Transition to Robins AFB will be pursued if demonstration and validation on DoD components is successful
  - Design and install automated and full-scale UADP system at Robins AFB B180 wet chemical de-paint facility
  - Design of the full scale system at Robins AFB in 2025 will be initiated for C-130 escape hatches, E-8 wheels, or similar aluminum alloy components currently de-painted in B180

Key Points

- UADP process has been optimized for specific Al and Mg alloys and paint composition
- Underlying anodizing layer is intact after de-paint processing using UADP process
- Typical UADP processing time 60-120 minutes
- Main process control parameters are
  - Sonication bath composition
  - Sonication frequency & power
  - Process temperature

BACKUP SLIDES

Publications

- 2019 ESTCP Symposium
- 2020 ESTCP Symposium
- 2020 ASETS Defense Workshop
- 2021 ESTCP Symposium

WP18-5031: Environmentally Friendly Paint Removal from Military Components

Performers:

- USAF (AFLCMC), UDRI, IBC Materials & Technologies, Inc.

Technology Focus

- Environmentally friendly PEDP (Plasma Electrolytic De-Paint) and UADP (Ultrasonically Activated De-Paint) technologies for paint removal from military components

Demonstration Site

- IBC Materials & Technologies, Inc. (Lebanon, IN)

Demonstration Objectives

- Qualify the process for aluminum- and magnesium-based alloys
- Adapt process for use on a variety of DoD components

Project Progress and Results

- UADP process has been optimized for specific Al and Mg alloys and paint composition
- Underlying anodizing layer is intact after de-paint processing using UADP process
- Typical UADP processing time 60-120 minutes

Implementation

- Demonstration and Validation of UADP Pilot Line at the Advanced Technology and Training Center (ATTC) near Robins AFB
- Transition to Robins AFB if demonstration and validation on DoD components is successful