AVT-339 Research Workshop on Robotics and laser/plasma – paint interaction in paint removal

Pulse Waterjet (PWJ) Stripping An Environmentally Friendly Process

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Canada

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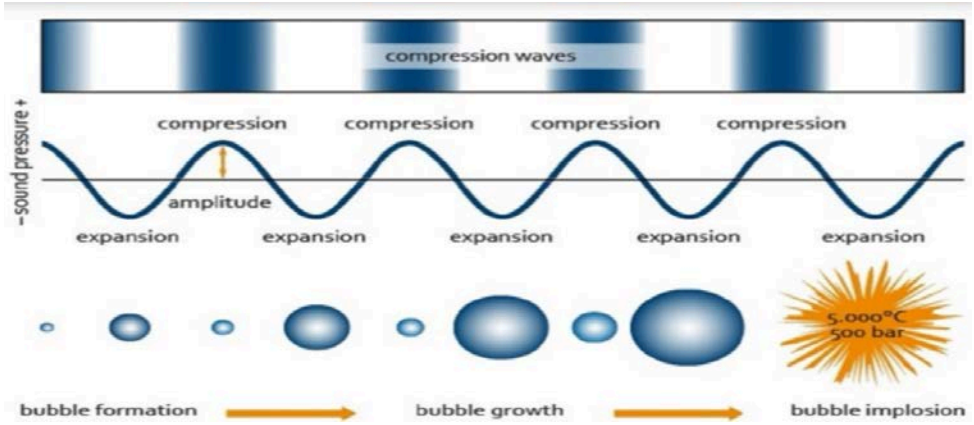
Presentation Overview

- Company History
- Technology Overview
- Benefits of Pulse Water Jet
- Industries that Uses PWJ
- Case Studies of Aviation Coatings Removal and Post Processing
- Soft Coating Removal – AntiSkid
- Automated TurnKey System
- Summary

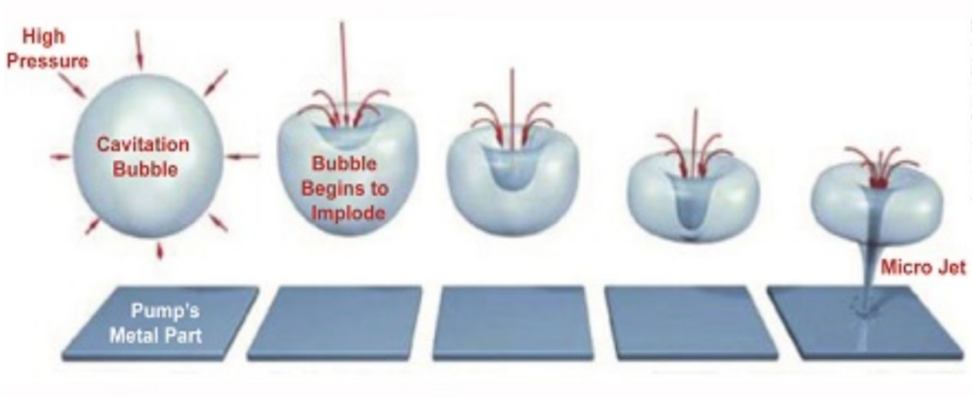
Company Overview

- VLN Advanced Technologies is Located in Ottawa, Canada.
- Dr. Mohan Vijay – a Pioneer in WaterJetting Science - Still Actively Working!
- Business Established in 1998
- Technology - Spin-Off of National Research Council of Canada (NRC).
- Main Product is Pulse WaterJet - International Patent.
- Commercialize Products to Various Industrialized Sectors
- Collaborate with Universities in Scientific Research and Development

General Cavitation Science

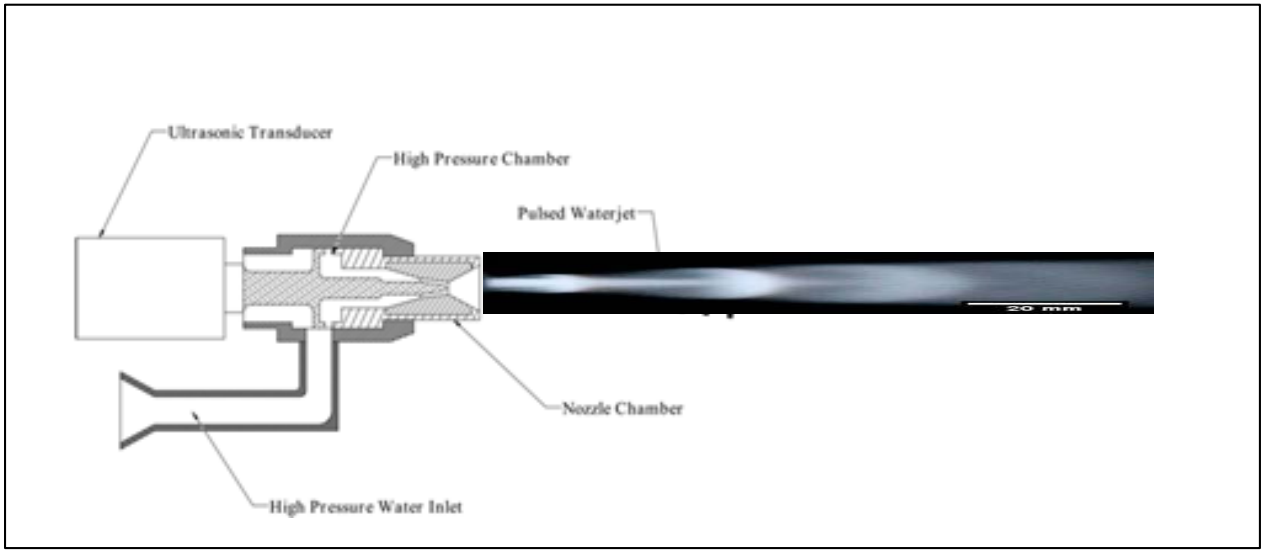


Powerful Sound Wave Travelling Through a Liquid Generates Low Pressure Zone That Produces Vapor Bubble Conditions.



Cavitation Void Form and Collapses Into Itself at Tremendous Pressure Creating a Micro Jet with High Intensity and Shock Wave.

PWJ Technology



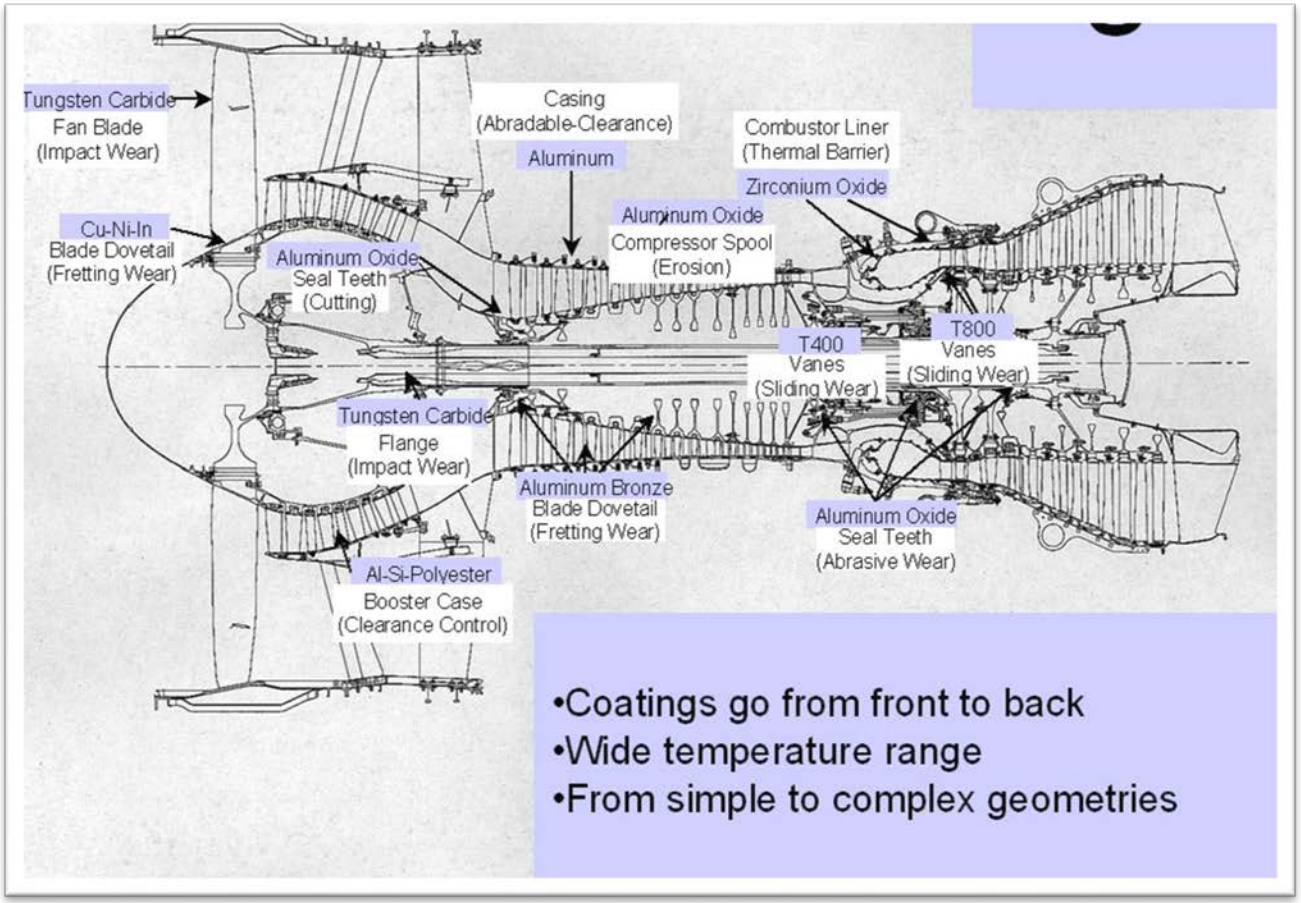
- High frequency (40KHz) ultrasonic wave produce rapid vapor pressure conditions.
- Vapor conditions create cavitation events.
- Cavitation events produced erosions caused by powerful microjets in a pressure field.
- Local Pressure can reach 1 million psi

PWJ Benefits

- Lower Operating Pressure (15,000 psi) = Lower Wear and Tear on Pump
- Low Consumables (Hoses, Fittings, Nozzles, Swivels etc)
- Only Uses Water - No Solid Media or Chemicals
- Water can be Recycled and Reused
- Ultrasonic Energy is very low ~ 300 Watts
- Can remove & selective strip extremely hard coatings and soft coatings
- Reduces multiple technologies / processes and costs.

Pulse Jet Uses in Aviation - Marine – Industrial - Nuclear

Hard Coating Uses in Aviation



Honey Combs – Fan Casing

Abradables – Seal segment

Chrome – Bearing Journals

Thermal Barrier Coating – Heat & corrosion protection

HVOF – Exhaust Nozzle Segment

Stripping HVOF on Landing Gear Pivot Pin - Case Study

Part Specifications

Material: 4340 M

Grit Blast: Alumina Oxide

Peened: Shot Peened

Surface Roughness: 125 µ in

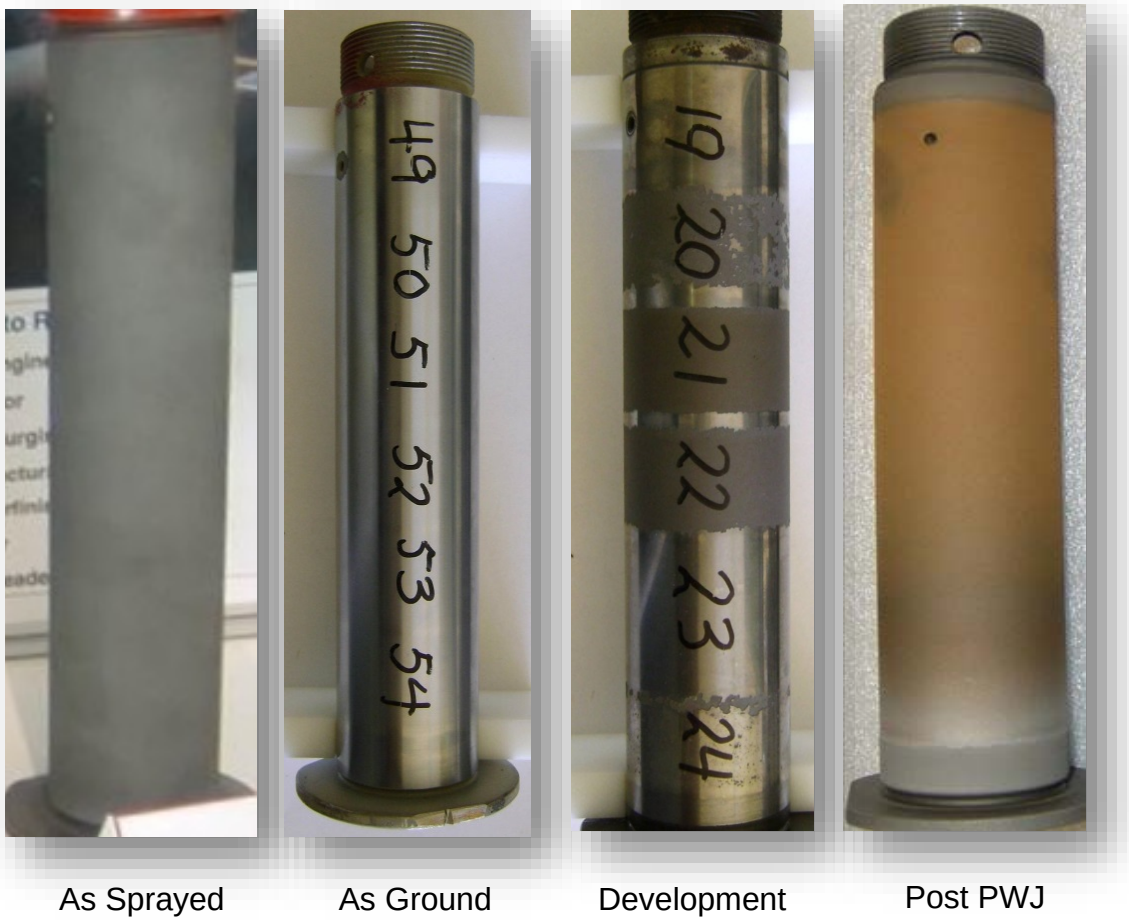
Water Jet Parameters

Pressure: 15,000 psi

Orifice: 0.055 inch

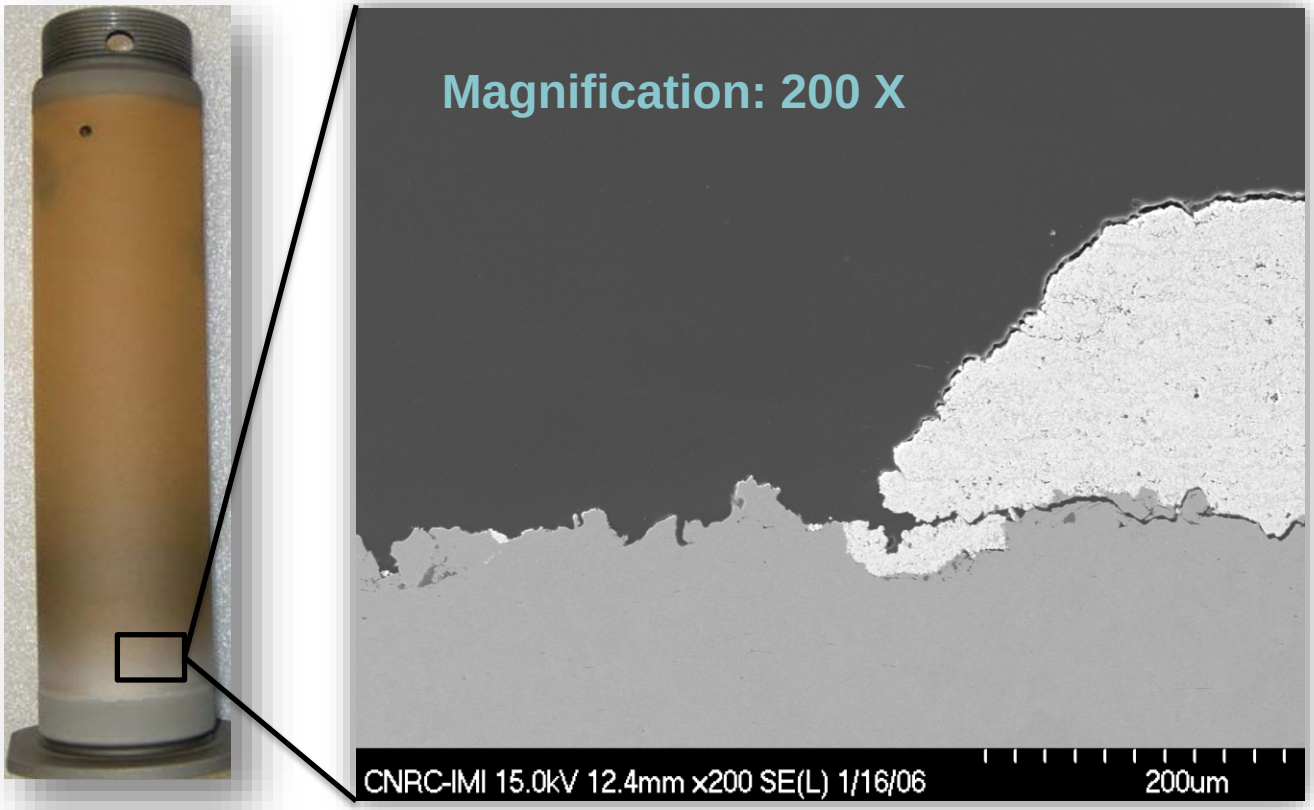
Flowrate: 9 gpm

Feed rate: Varies



As Sprayed | As Ground | Development | Post PWJ

SEM – Profile of Coating Substrate Interface



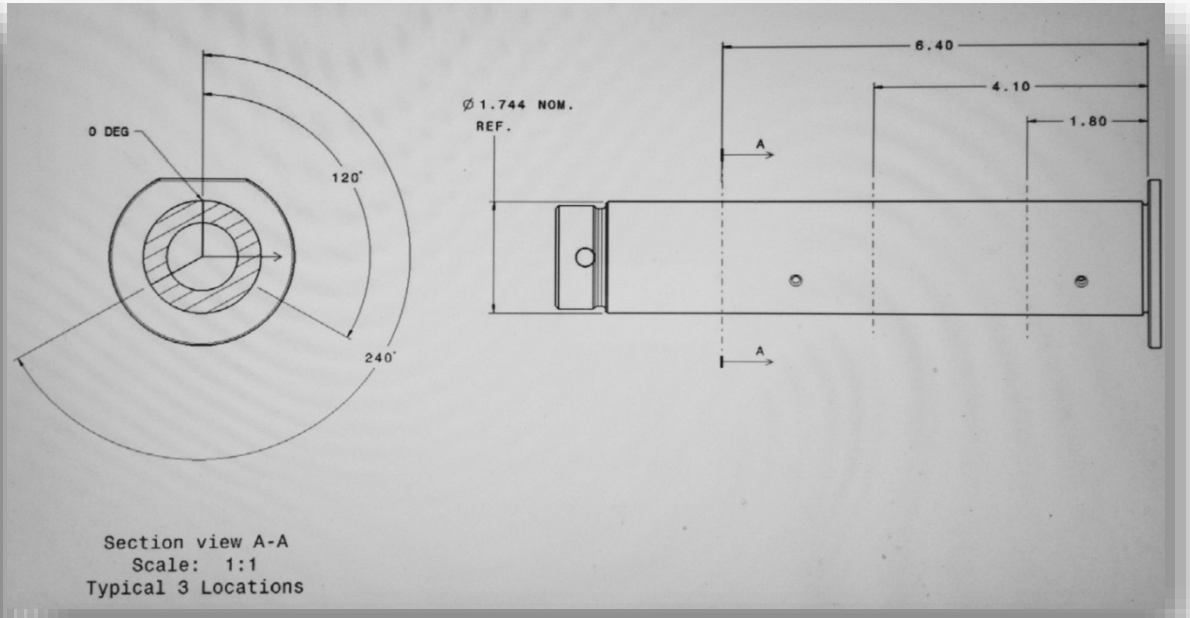
Post Stripped

- No mass loss
- No increase in Surface roughness
- Deep Stripping
- Flash rust

Coating Specifications

- WC-Co-Cr (HVOF)
- Thickness = 0.015-in
- Modulus: 40 Mpsi
- Hardness: 1220 Vickers
- Bond Strength: 10 kpsi

XRD Analysis - Proto

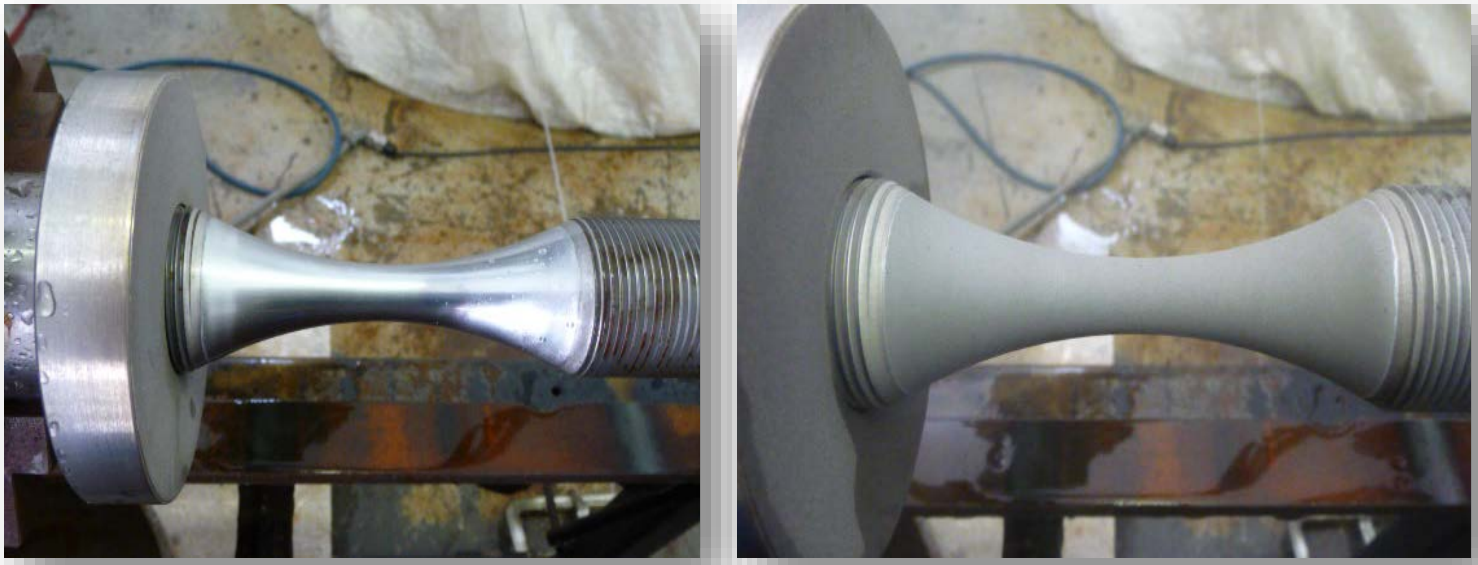


CONCLUSIONS

1) Residual stress measurements were successfully performed on a three steel pins identified as S/N DCL2393, S/N DCL2394 & S/N DCL2400 by Messier-Dowty Inc.

2) Surface residual stress results were all compressive and varied from –107 ksi to –131 ksi.

Fatigue Bar Test – Thick (0.012”) Chrome Plating & Ground



Typical appearance of the coupon coated with thick (0.012”) chrome: before stripping (left), after stripping (right).

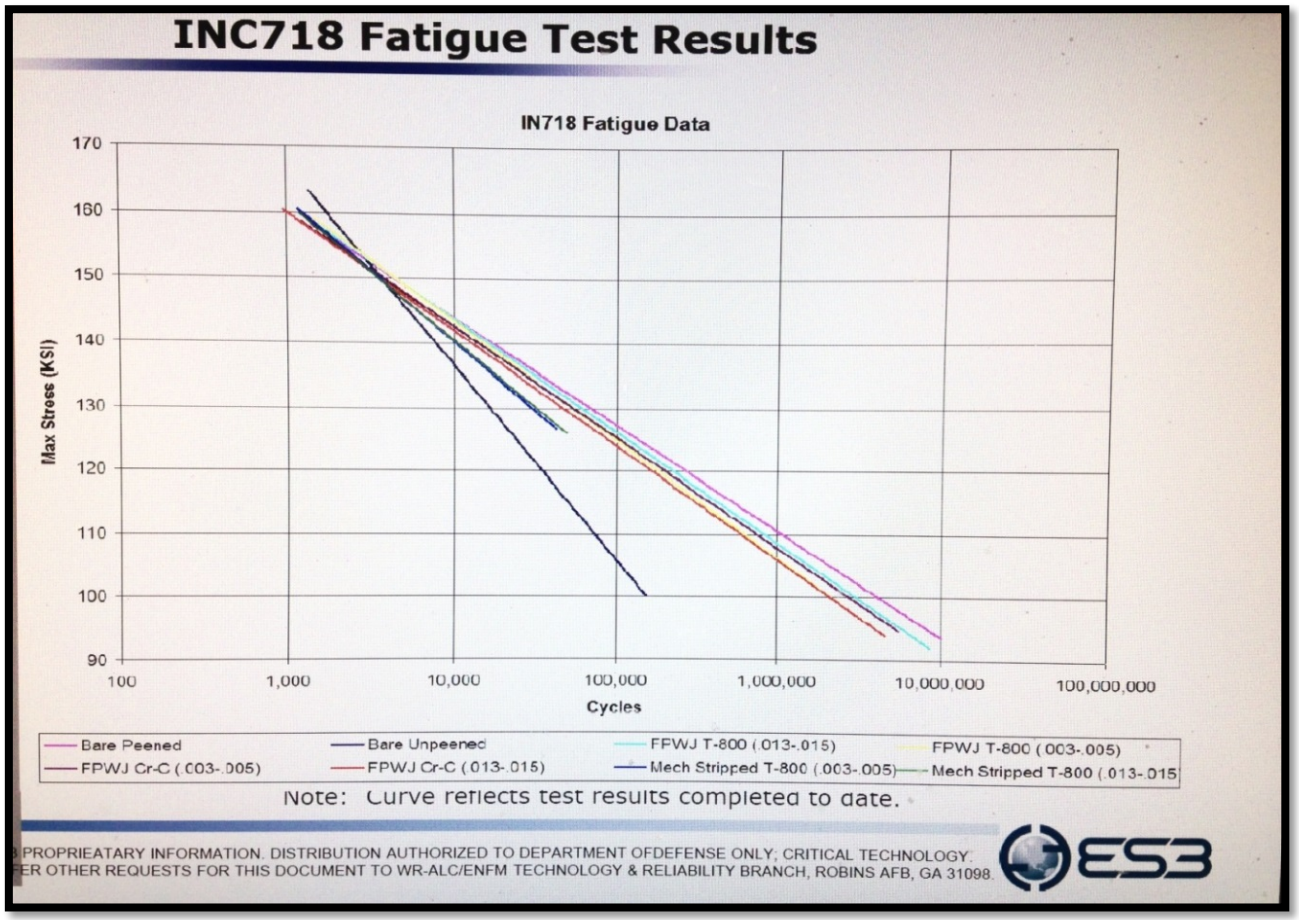
16 specimens tested for each coating scheme. Pressure: 15,000 psi. Nozzle: 0.055” N: 600 rpm V: Varies Passes: 1

Measurements of before-and-after at gage section: Surface roughness Ra, Diameter, Weight of bar

Bending Fatigue Test Results S-N Curve

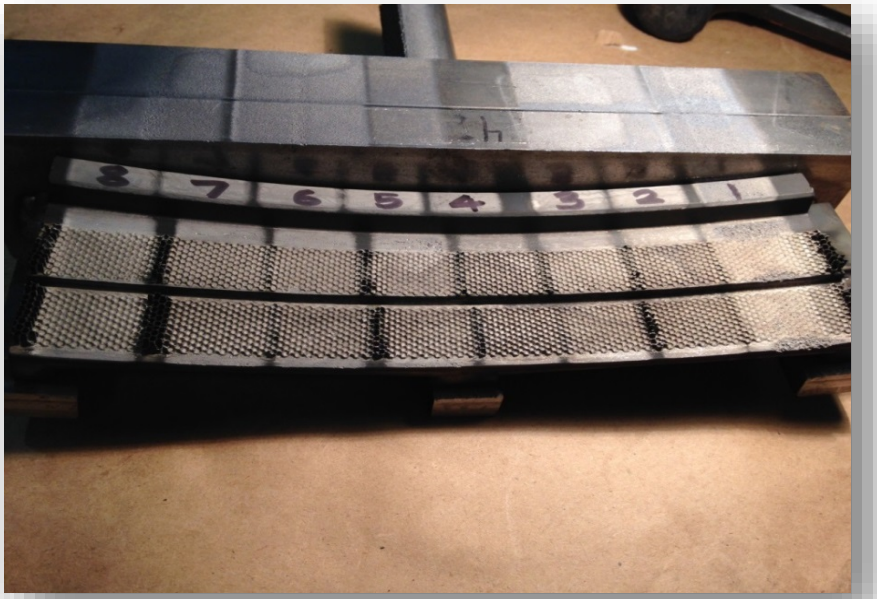
Post PWJ strip:

- 2 HVOF & 2 Chrome coating schemes
- 16 bars per type
- Did not undo peening
- Better than baseline
- Better than mech. stripped (part broke)
- Similar to as peened
- Max stress remained
- Failure at cycle limit



Other Hard Coatings Stripped by Pulse Jet

Combustion Outer Liner - Inconel/TBC
- **Pratt & Whitney US**



Honey Comb Segments – Inconel/Nickel
- **Delta Airlines**

Metallic Coatings for Industrial Applications

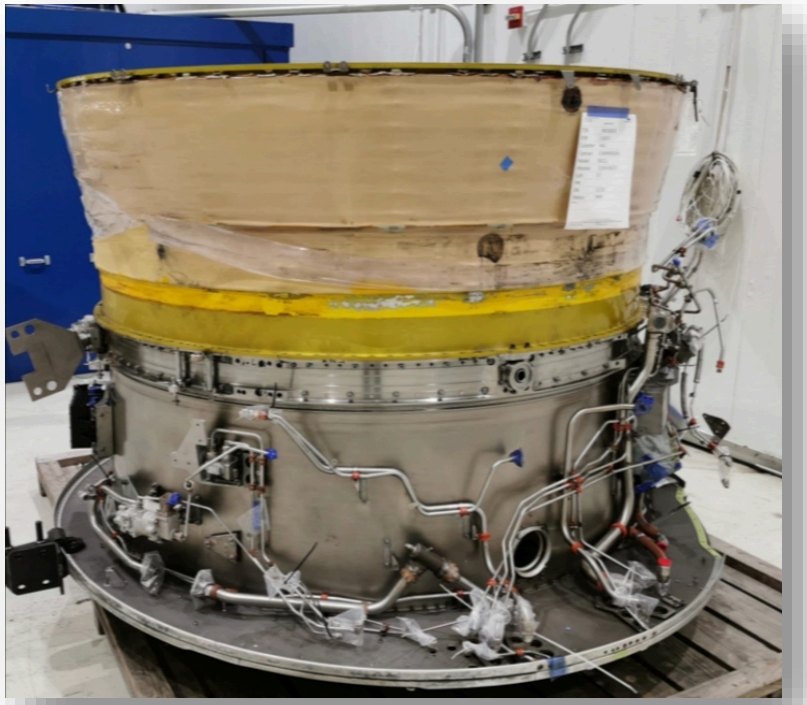
Print Roll - S.S Coating 0.006” thick removed at 10,000 psi. - **St Louise Metallizing**

Hydraulic Shaft – Chrome Coated 0.003” Thick removed at 10,000 psi. - **Caterpillar**

Coatings and Substrate Schemes Stripped by Pulse Water Jet

Substrate Materials	Coating
Inconel 625	TBC
Inconel 718	WC-Co
Inconel 718	718 Inc. HVOF
Inconel 718	73 mxc Arc Wire Spray
Inconel 718	T-800
Inconel 718	Cr-C
Inconel	NiCrAlY
1020 Steel	1343VM HVOF
410 S.S	Serme Tel “W”
300M	WC-Co-Cr
300M	Cr
300M	WC-Co-Cr
4340	Cr
4340	WC-Co-Cr
4340	Cr
4340M	WC-Co-Cr
Magnesium Alloy	Aluminized epoxy enamel
15-5PH	WC-Co-Cr
15-5PH	Cr
Ti 6AL-4V	WC-Co-Cr
Ti 6AL-4V	CuNiIn
Al 6061	NiAl
Al 1100	WC17Co

RB211 Gas Turbine Fan Casing Overhaul



Inlet Stage Side View of Fan Casing

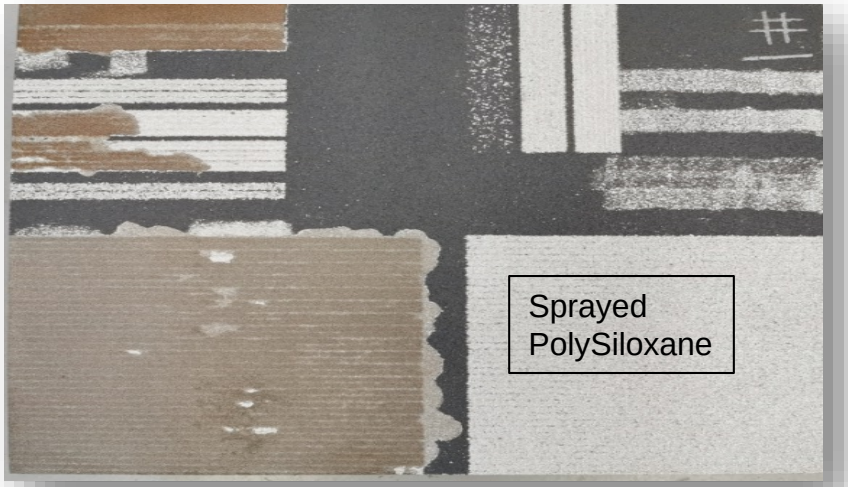
Front View - Post Waterjet Stripping

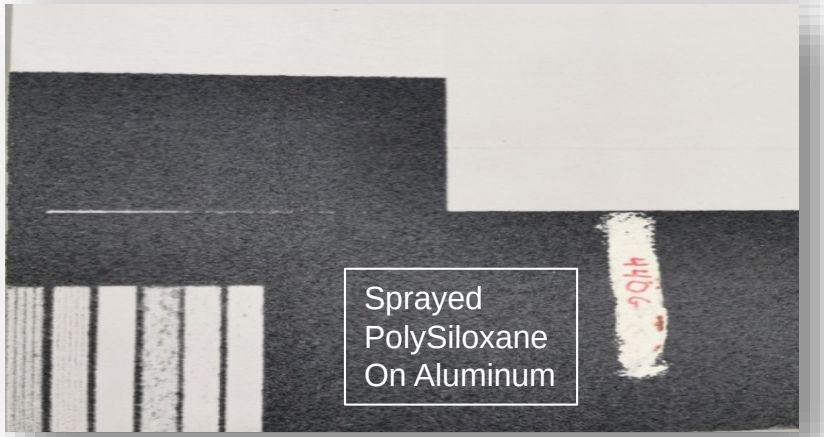
RB211 Gas Turbine Fan Casing Overhaul Manual

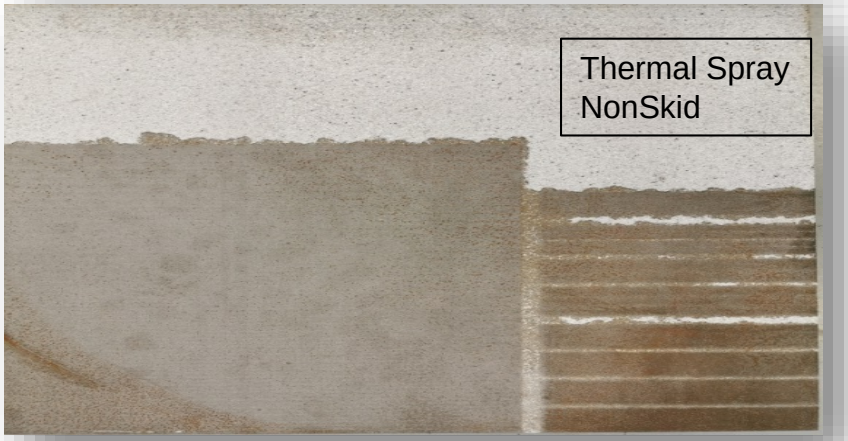
Manual Operations require 2 weeks
Water Jetting require 2 days
PWJ requires 2 hrs

Navy Non-Skid Coatings and Substrate Schemes Stripped by Pulse Water Jet

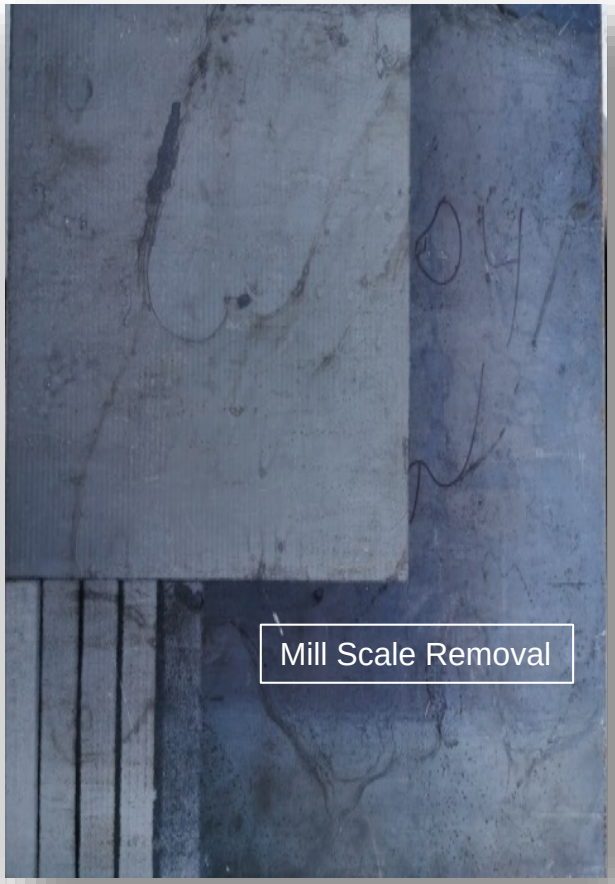
Marine Non-Skid Coatings and Substrate Schemes Stripped by Pulse Water Jet

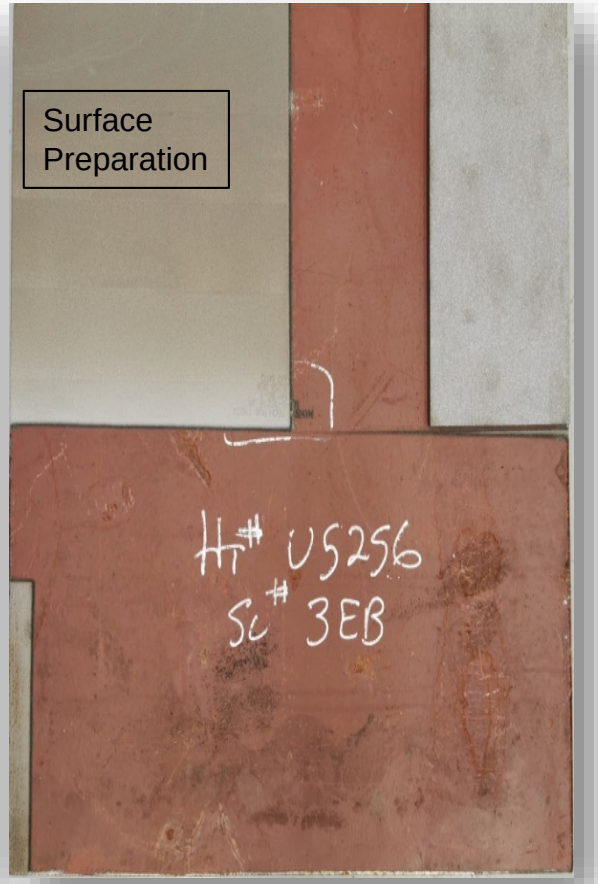




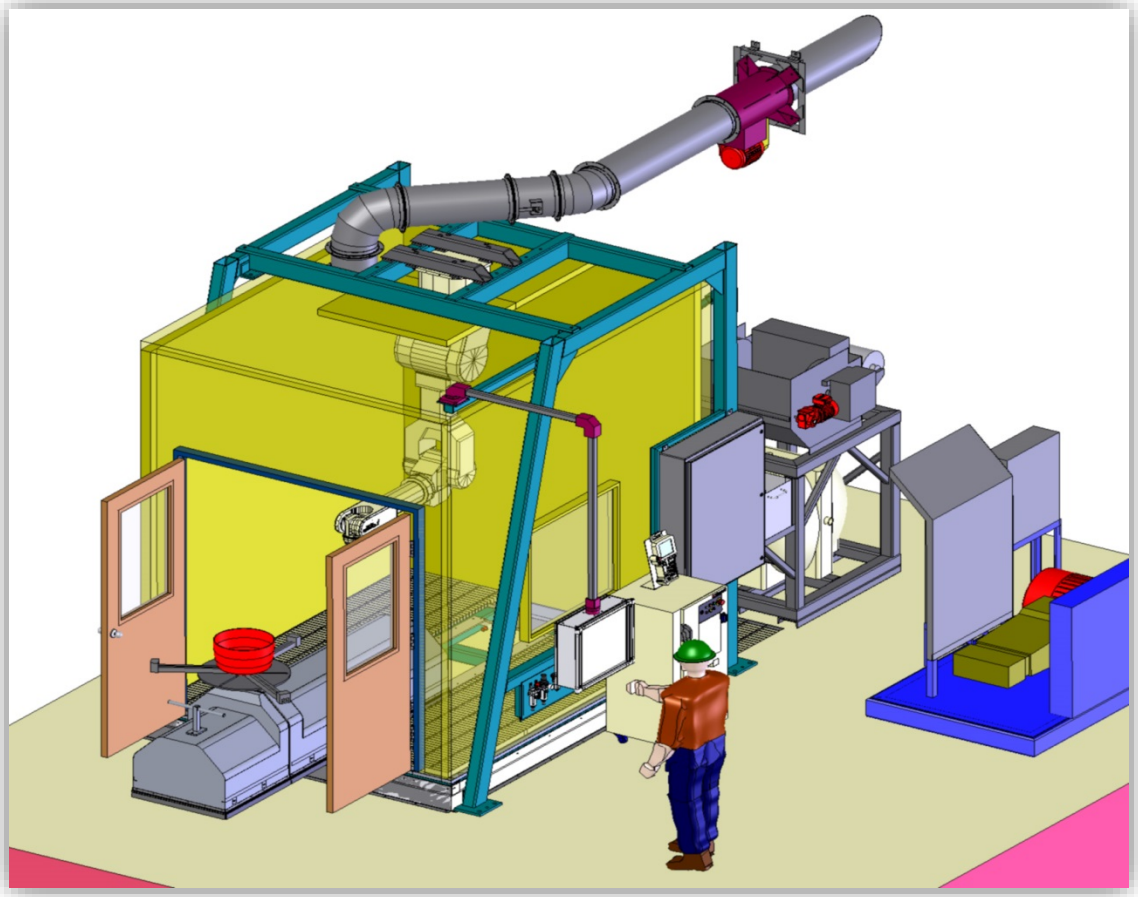


Selective Stripping and Surface Profile Prepping





PAWS – Pulse Automated Waterjetting System

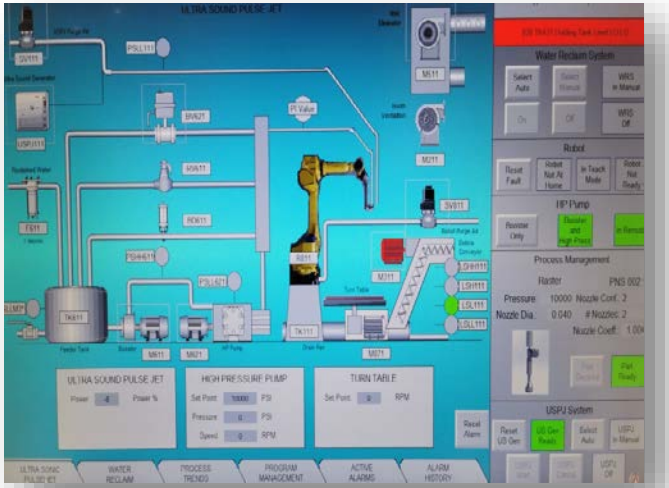


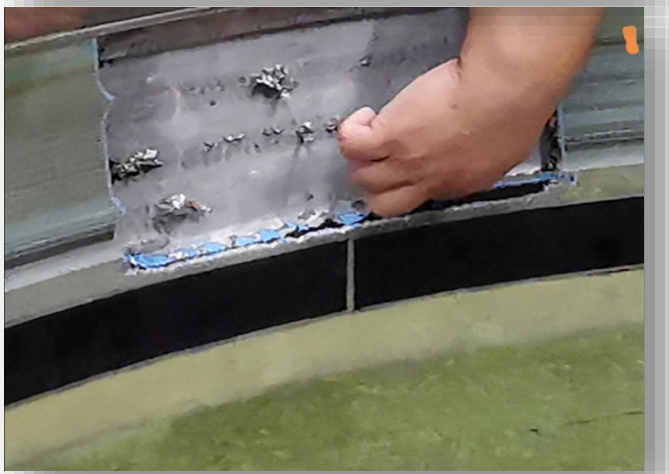
- Fully Automated - one person operation
- Small foot print all-in-one system
- Uses only water & operate at low pressure.
- Closed loop water filtration & recirculation
- Accurate & repeatable process
- Waste by-product is only solid particles
- Line-of-sight technology

PAWS in *MRO Facility*

Features

- 15 Ksi PWJ
- Telescoping Crane
- 10 ft diameter Part
- Servo Drive Turn Table (2,500 lbs)
- Programmable 6-Axis Robot Arm
- Custom Developed HMI Process Screen
- 75 dB Sound Level Outside
- Stainless Steel Interior
- Full Operating Manual





Summary

- Using Science to Maximize Result and Minimize Energy Spent
- Uses No External Media Source to Reduce Waste and Cost
- Combines Multiple Processes Into One
- Low Operating and Investment Cost
- Increase Turn Around Time
- Automated Process Controlled by Single Operator
- Environmentally Clean and Safe Technology

Thank You!

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Questions

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