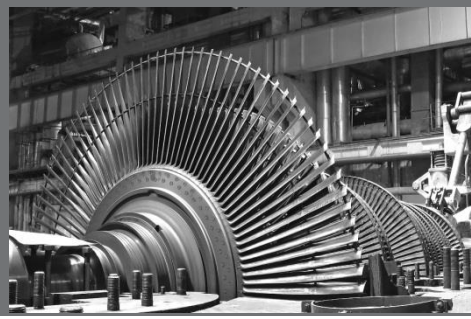
CURTISS-WRIGHT

Surface Technologies Division

Introduction to Curtiss-Wright

Peter Ruggiero

Regional Manager, Surface Technologies Division



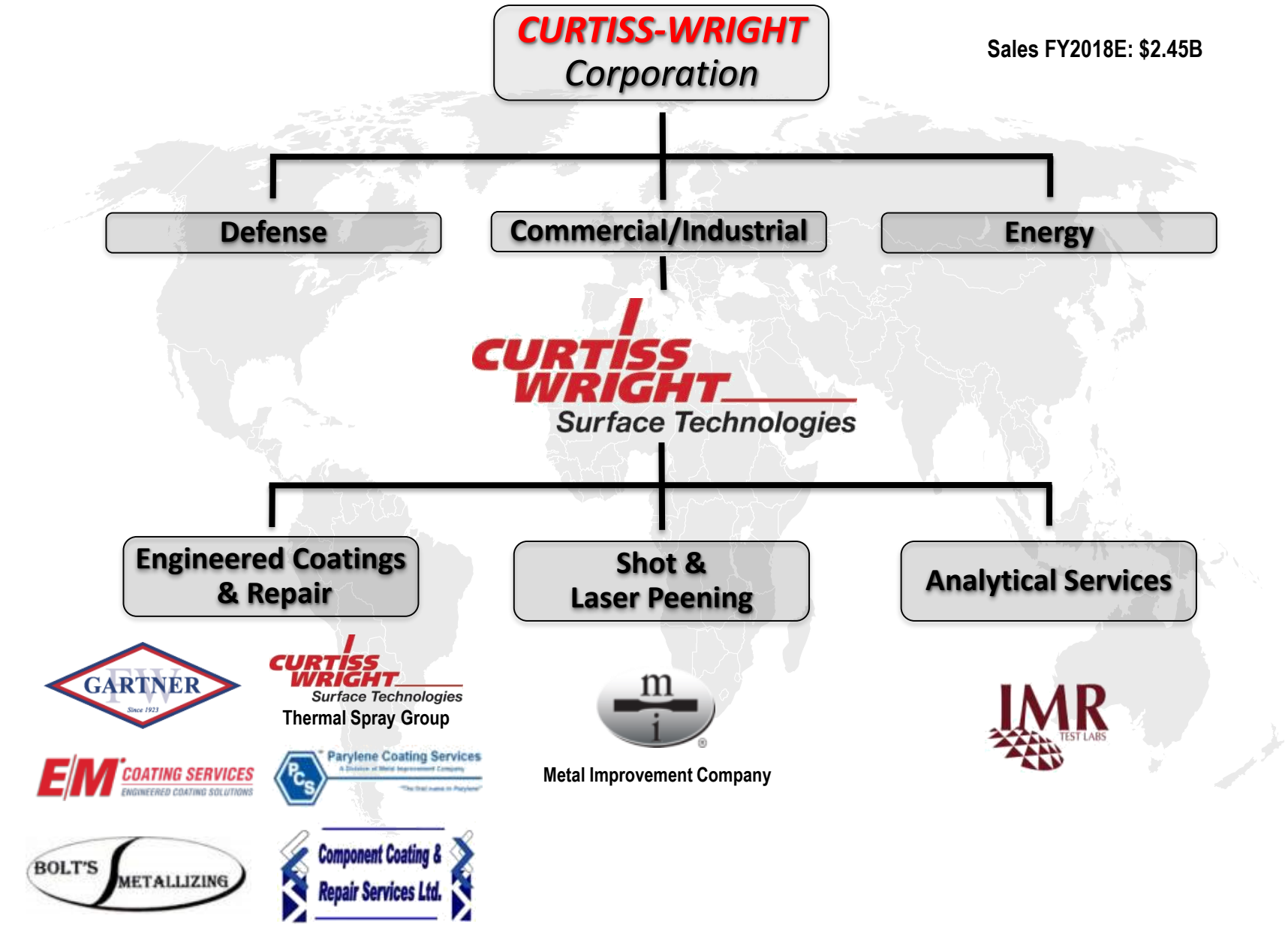
CURTISS-WRIGHT

Curtiss-Wright Corporation History

Tracing its roots to the Wright Brothers & Glenn Curtiss

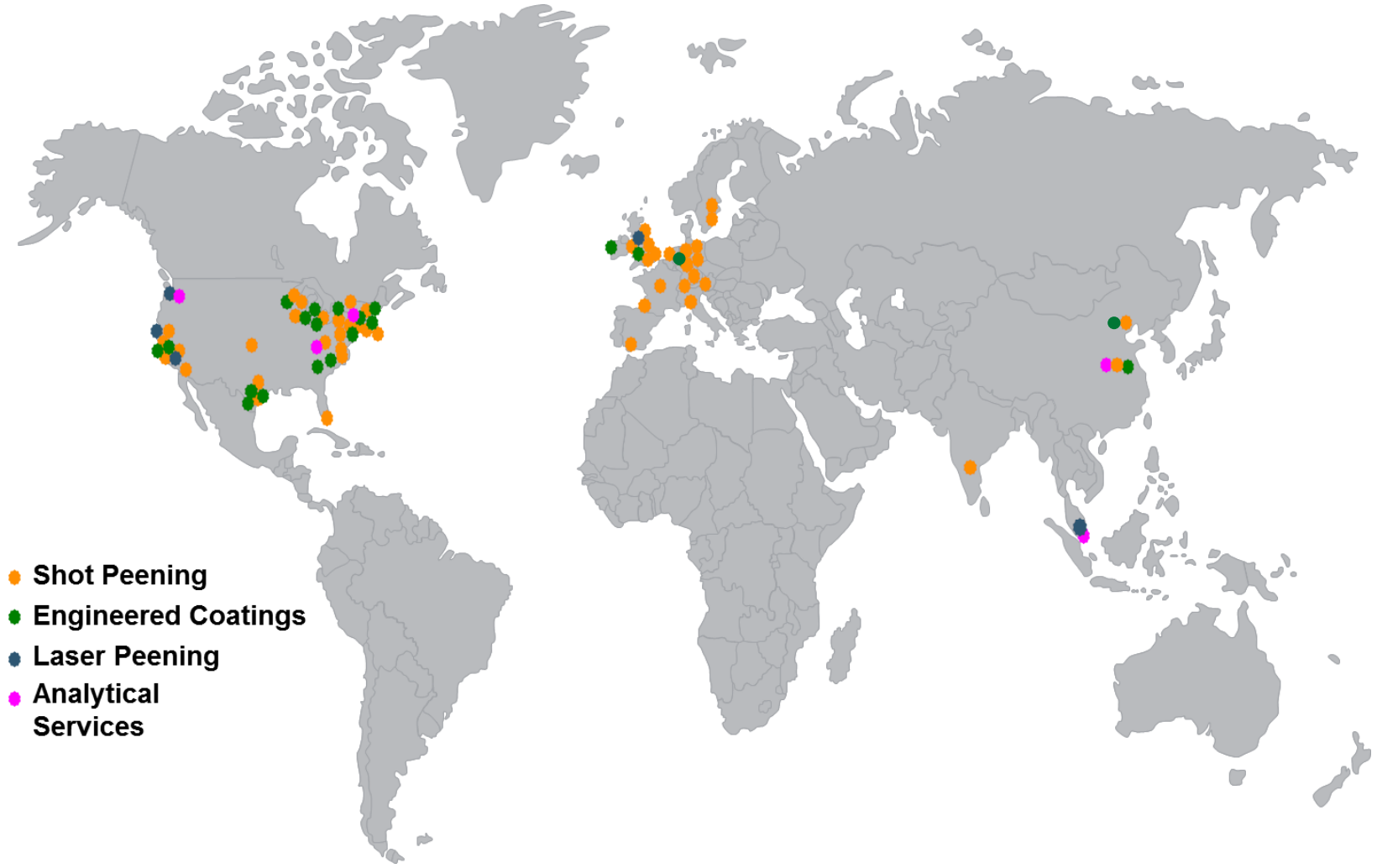
CW LISTED NYSE

Curtiss-Wright - Organizational Chart



CWST – International Business Units

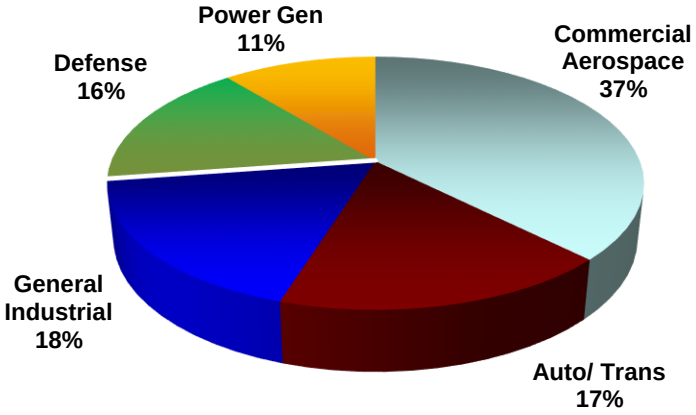
- Over 75 Business Units Worldwide



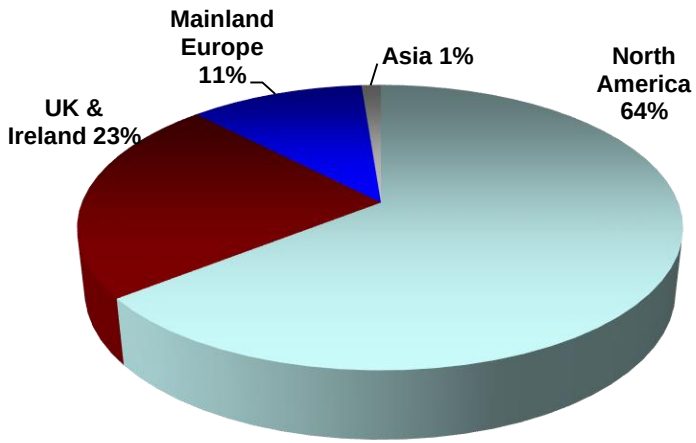
Business Snapshot

- **Commercial Aero - Primary Market**
  - Aero structures & turbine engines
  - Emphasizing diversified growth in demanding industrial markets
- **Shot Peening - Primary Technology**
  - Future emphasis on Engineered Coatings
- **N. America (2/3) and Europe (1/3)**
  - Supporting International OEM's

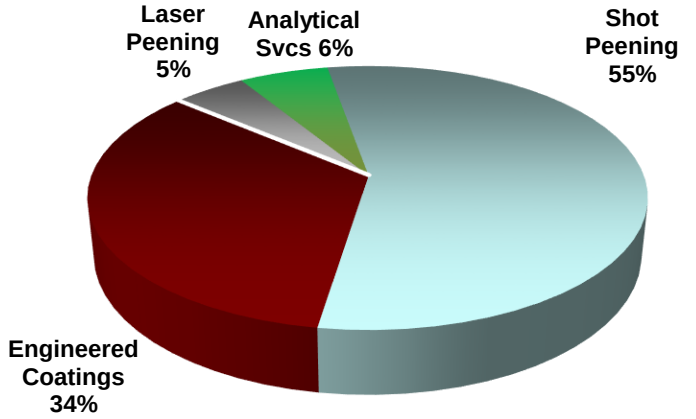
Sales by Market



Sales by Geography



Sales by Technology



Curtiss-Wright Surface Technologies

- Application of appropriate surface technologies to enhance the performance of materials

Controlled Shot Peening

Shot Peen Forming

Parylene Coating

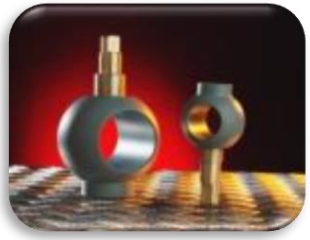
Component Coating & Repair

Laser Peening

Isotropic Finishing

Analytical Services

Thermal Spray



Engineered Coatings

Engineered Coatings

- **Facilities:**
  - **15 North America**
    - 5 Thermal Spray
      - 65 Thermal Spray cells
        - 3 Dedicated Development Cells
    - 8 Solid Film Lubricants
    - 1 Parylene
  - **5 Europe**
    - 3 in UK - Thermal Spray & Sacrificial Aluminum
    - Germany – Solid Film Lubricants
    - Ireland - Parylene
- **Capabilities:**
  - **Thermal Spray Coatings**
    - TBC, MCrAlY, Ceramic & Carbides
  - **Laser Cladding & PTA Weld Repair**
  - **Liquid "Spray & Bake" Coatings**
    - Solid Film Lubricants,& Sacrificial Aluminum Coatings
  - **Parylene Conformal Coatings**

CWST Thermal Spray Business Units

FW Gartner
99K SQFT

East Windsor, CT
70K SQFT

Duncan, SC
22K SQFT

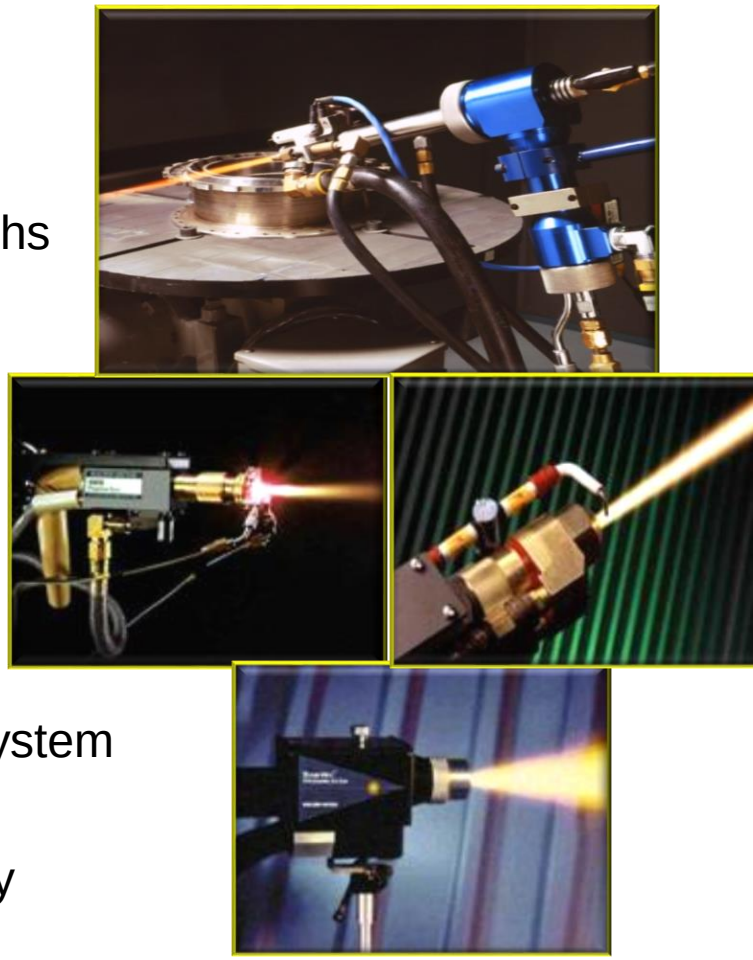
Wilmington, MA
24K SQFT

Phoenix, AZ
20K SQFT

East Windsor, Connecticut

Overview

- 70,000 SQFT
- 20 production booths
- 3 dedicated R&D and Engineering booths
- 13 HVOF systems
- 17 Plasma systems
- 2 Wire, 1 twin & 1 M10E



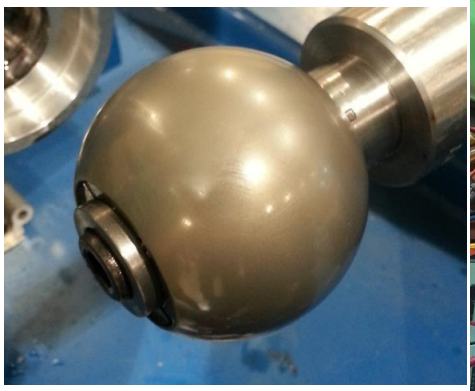
Certifications

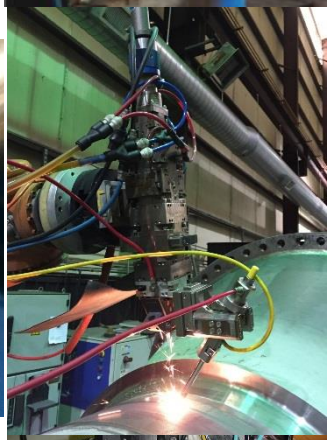
- NADCAP
- ISO 9001/AS9100 Aerospace Quality System
- FAA Certified
- EASA, European Aviation Safety Agency Certified
- All Major OEMs

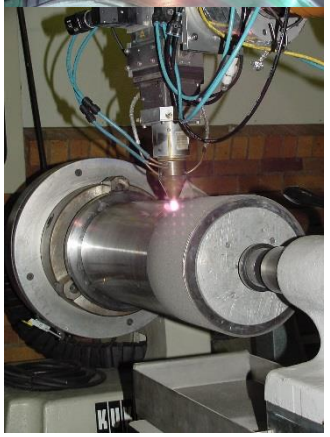
Pearland, Texas

Overview

- 99,000 and 25,000 SQFT
- 13 production booths
- 3 dedicated R&D and Engineering booths
- 11 HVOF systems
- 17 Plasma/Combustion systems
- 1 Cold Spray System; 1 Uniquecoat
- 5 Laser Systems
- 3 PTA Systems
- Multiple Machine and Grind stations
- ID and OD Grind
- Milling







Certifications

- NADCAP(Just acquired in 2018)
- ISO 9001 Quality System
- All Major Oil and Gas OEMs
- GE and Siemens IGT Repairs

Wilmington, Massachusetts

Overview

- 24,000 SF
- 8 Production spray booths
- 7 TS Systems, 2 HVOF, 1 Flame Spray, 1 Arc Wire
- 4 Shotpeen, 1 Robotic controlled cabinet, 3 Micro Switch Controlled

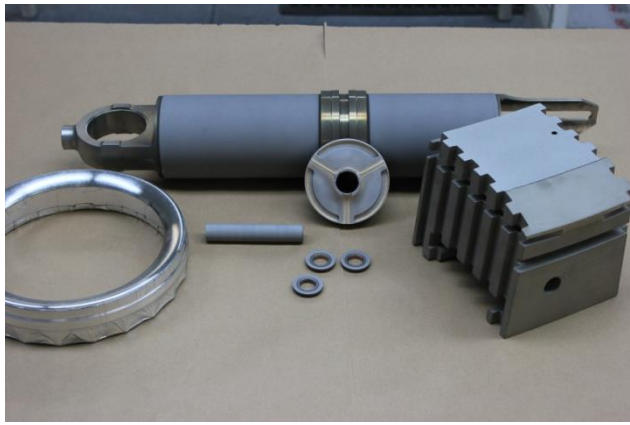
Certifications

- NADCAP
- ISO 9001/AS9000 Aerospace Quality System
- GEAE
- Siemens
- Innovent

Phoenix, Arizona

Overview

- 20,000 SQFT
- 7 production booths
- 2 HVOF systems
- 5 Plasma systems
- 2 twin wire
- Heat treat
- Brazing
- Welding
- Dry Film Lube
- FPI(Quals in process)



Certifications

- NADCAP
- ISO 9001/AS9100 Aerospace Quality System
- FAA Accredited
- Honeywell
- UTAS/Hamilton Sunstrand
- Rolls Royce

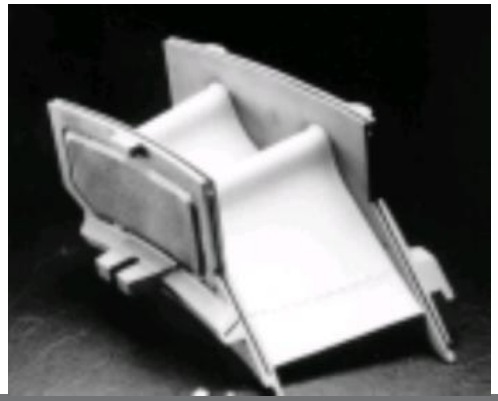
Duncan Facility Capabilities

Overview

- 36,000 SQFT
- 6 production booths
- 8 HVOF systems
- 5 Plasma systems
- 1 Arc Wire
- Heat Treat-Sm Vacuum Furnace

Certifications

- NADCAP
- ISO 9001/AS9100 Aerospace Quality System
- GEPS
- Rolls Royce

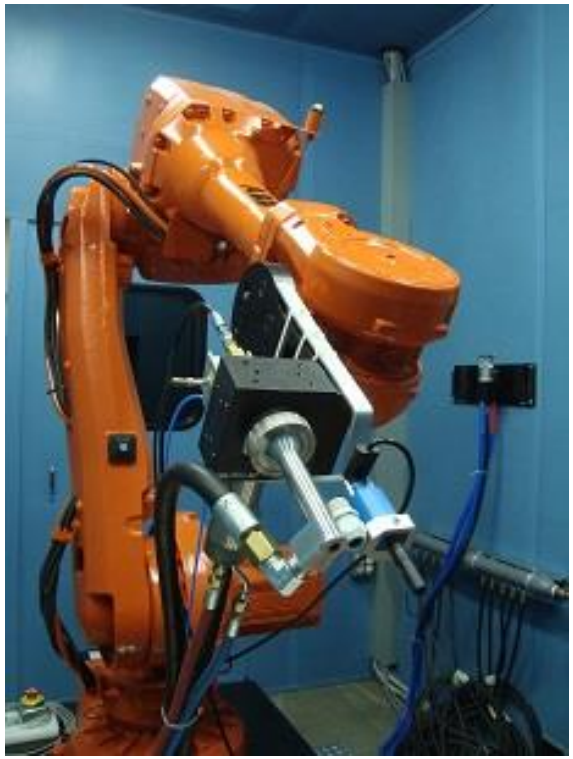


Engineering - R&D Facilities

3 Dedicated Booths for R&D Engineering

- 1 Standard Acoustic Booth with multiple TS systems
- 2 Double-Sized Booths with fully automatic TS Systems.
- Latest computer and mass-flow controlled multi-process TS systems, fully integrated with Robot with 2- axis Index Turntable with safety features

R&D Booth #31

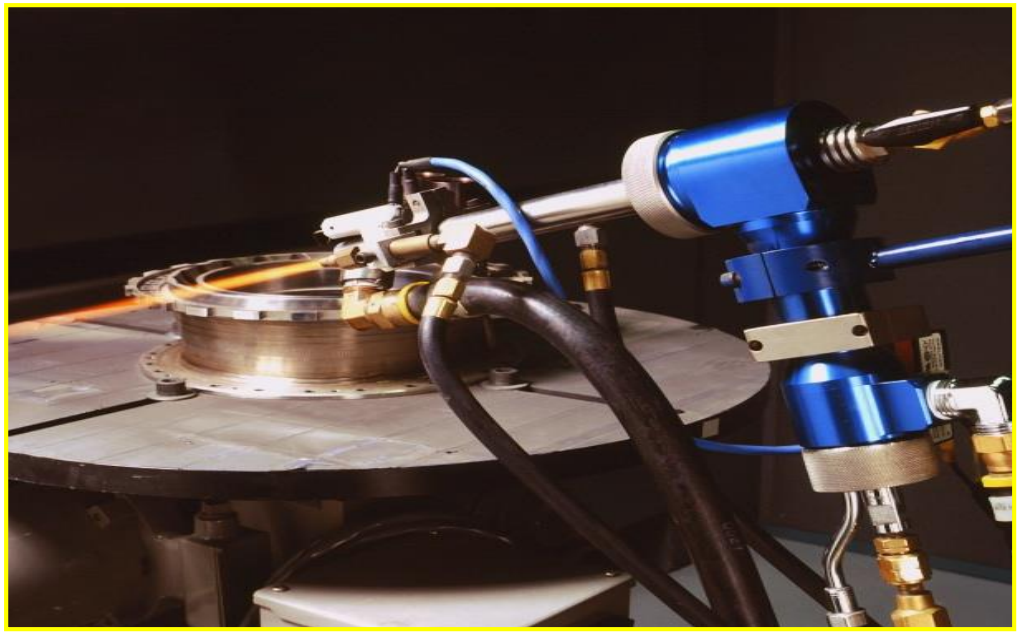


Booths with integrated robot and multi-process TS System

R&D Team Functions

What is Thermal Spray?

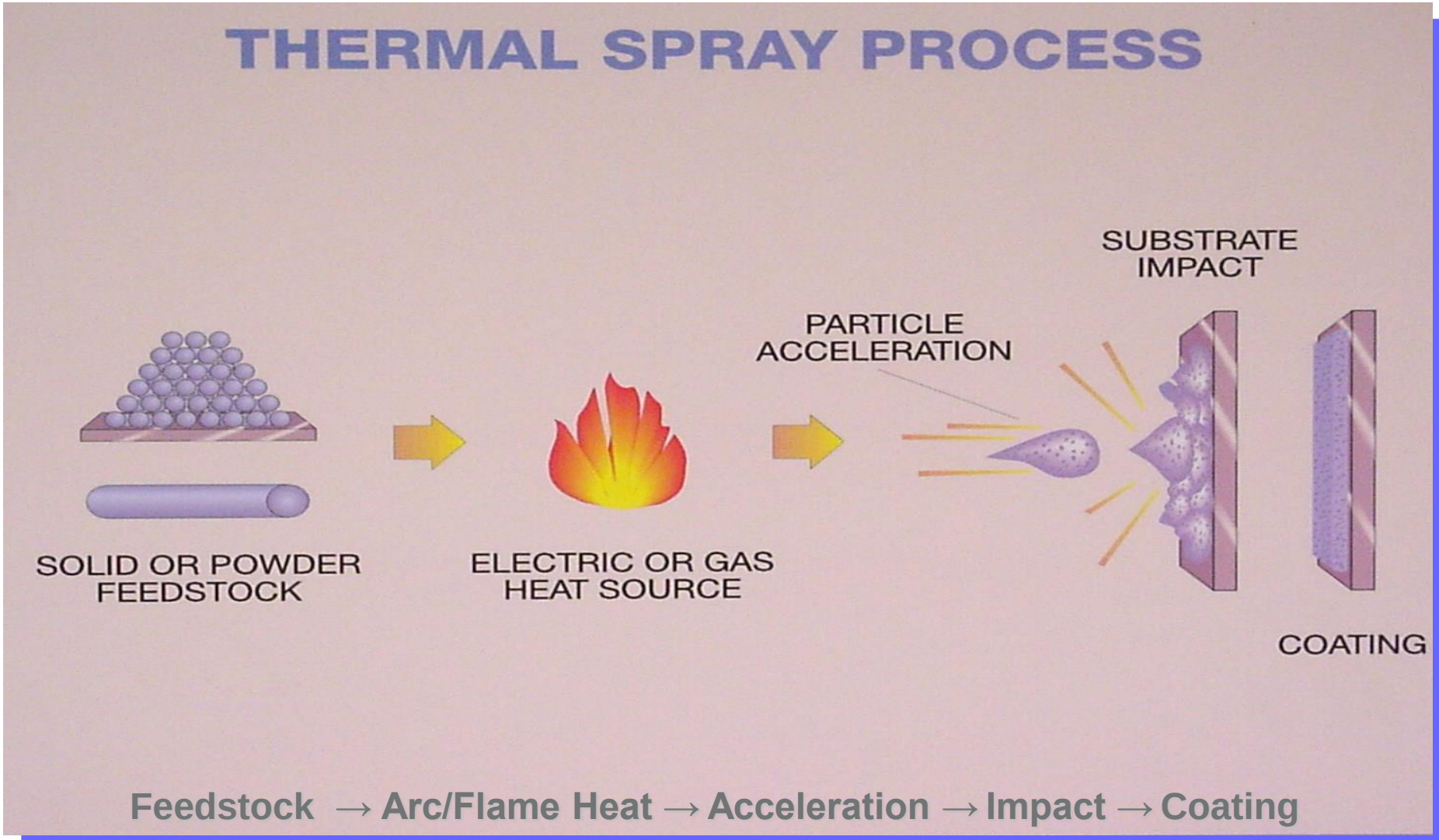
The Thermal Spray Process



Thermal Spray is a family of processes by which an energy source is used to heat materials and propel them onto a substrate thus forming a coating.

The resulting coating enhances the performance of a substrate

The Process



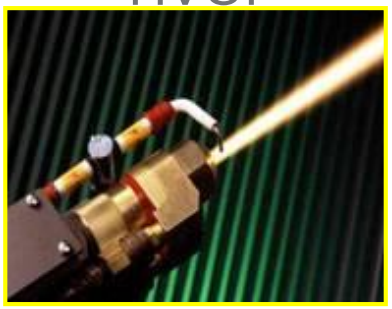
Feedstock → Arc/Flame Heat → Acceleration → Impact → Coating

Thermal Spray Family

- Plasma Spray
  - Air Plasma Spray (APS)
  - Low Pressure Plasma spray (LPPS)
- High Velocity Oxygen Fuel (HVOF)
- Combustion Flame
- Electric Arc
- Cold Spray
  - Kinetic Metallization

Plasma

HVOF



Combustion

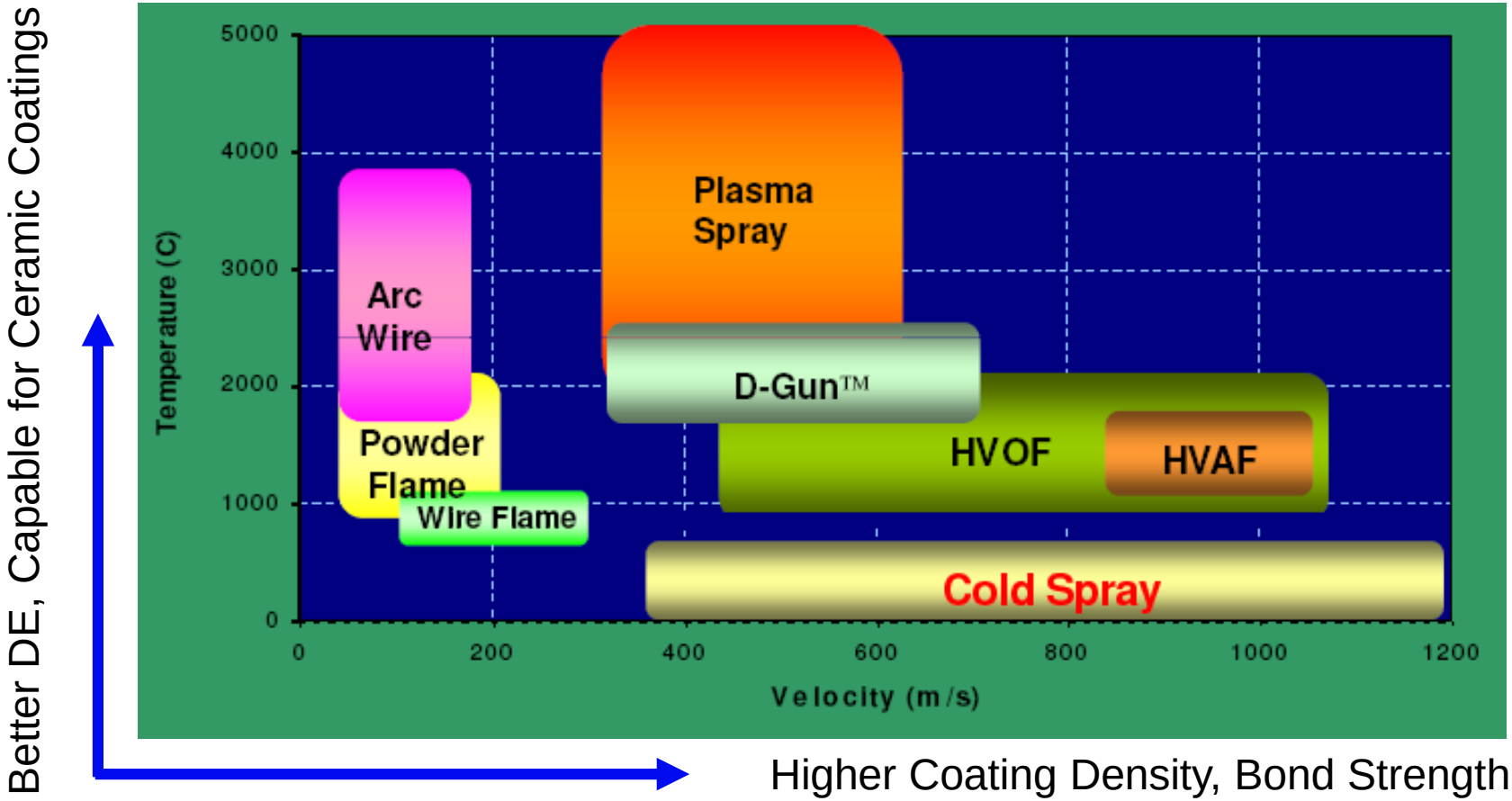
Electric Arc

Combustion

Cold Spray

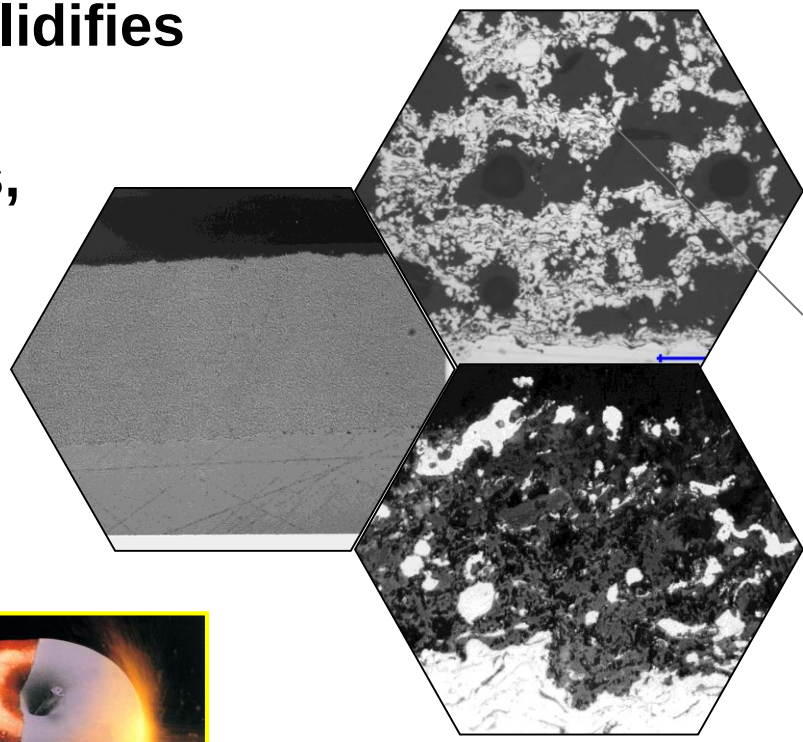
Process Characteristics

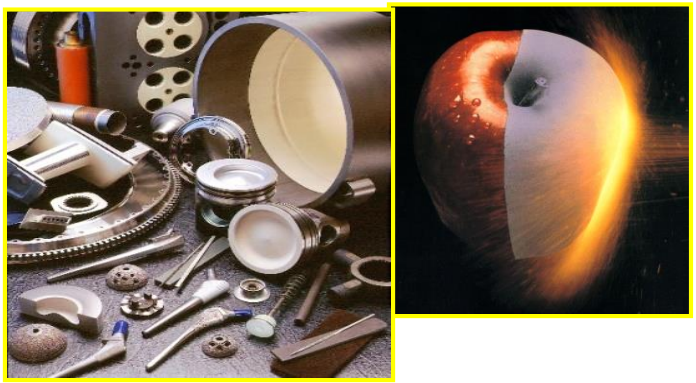
➢ Key Forces: Flame Temperature & Velocity



Process Versatility.....

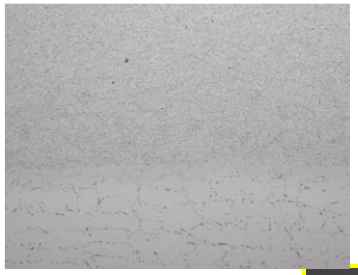
- **Unlimited Coating Possibilities**
  - **<u>Any</u> Material that Melts and Re-solidifies can be applied as a Coating**
  - **Metals, Oxides, Carbides, Nitrides, Borides, Silicide, Polymers**
  - **Combination of the Above**
- **Most Substrates can be coated**
  - **Metals, Ceramics, Glass, Plastics**



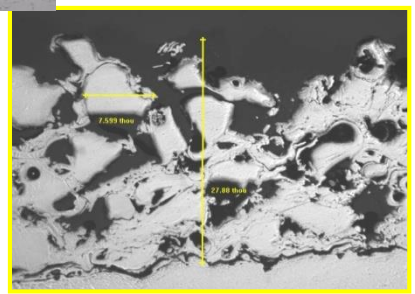


Technology Versatility.....

- Any Size or Shape
  - Small / large
  - Limited by line of sight



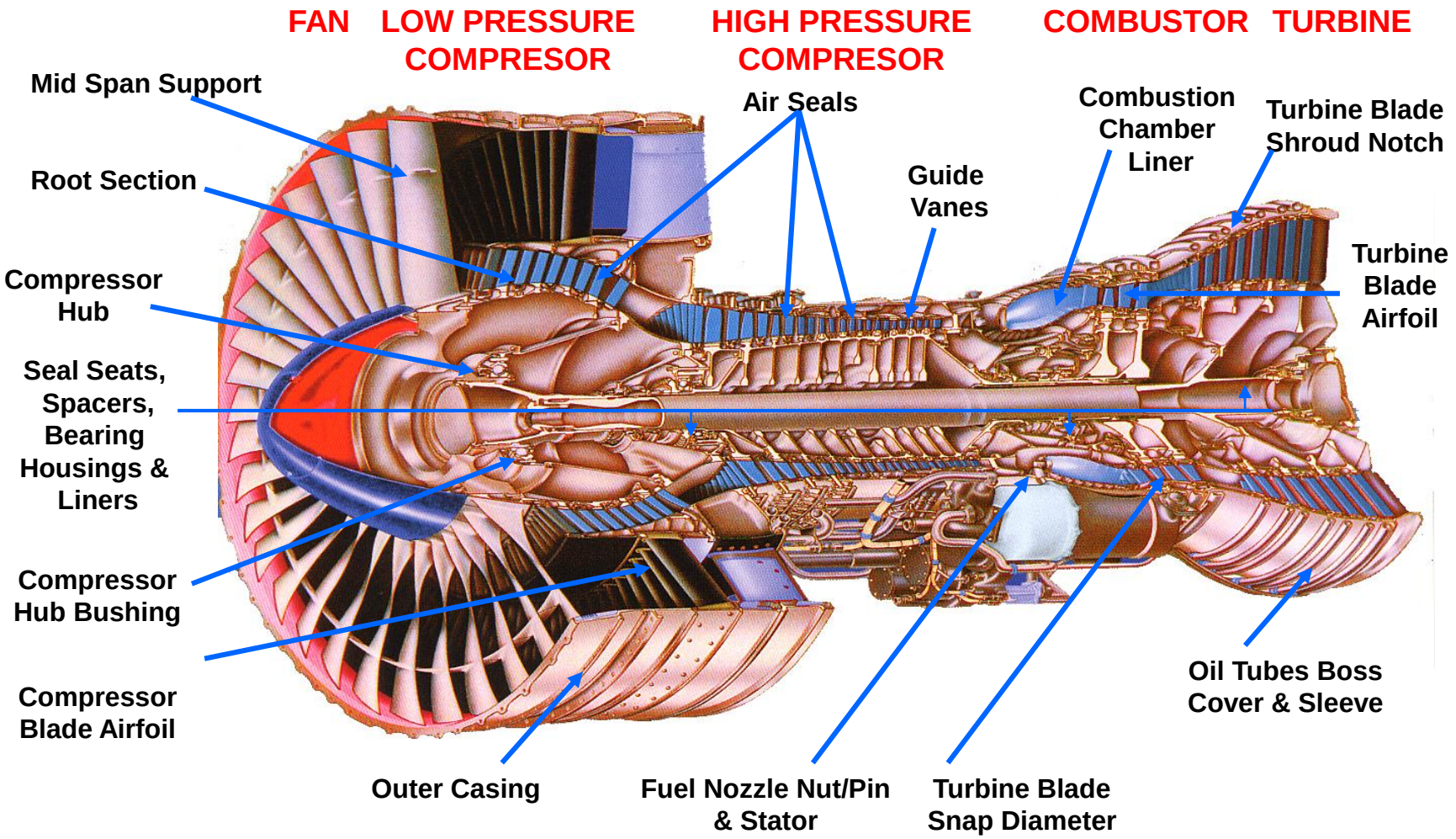
- Surface Enhancement
  - Thick (.200in) / Thin (.002in)
  - Dense (<1% porosity) / Porous
  - Smooth < 2rms as ground
  - Rough 400 rms as sprayed



Functions of Thermal Spray Coatings

- **Environmental Protection**
  - Thermal Insulation & Barrier
  - High Temperature Oxidation
  - Atmospheric Corrosion
- **Wear Resistance**
  - Abrasive
  - Fretting
  - Erosion
  - Cavitation
- **Clearance Control**
  - Cutting
  - Abradable Sealing
- **Build-up and Reclamation**
  - Dimensional Recovery
  - Local Repair
  - Net Shape Forming
- **Functional Coatings**
  - Dielectric
  - Antifouling
  - Non-skid
  - Biomedical Implants
  - Ion Conductor – SOFCs
  - Gas Sensors

Aerospace Coating Applications

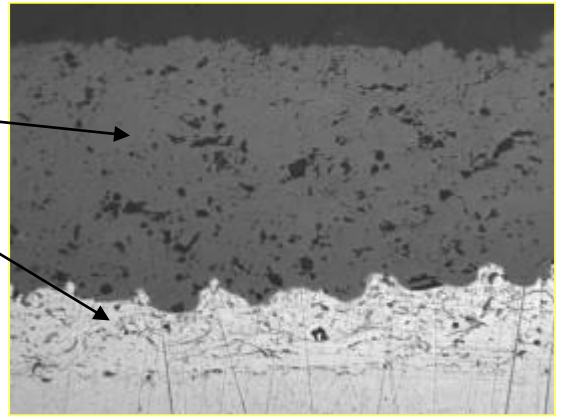


Thermal Barrier Coatings (TBCs)

- **TBCs provide thermal insulation & barrier for turbine components at elevated temperature**

TBC of duplex Layers:

- Porous ZrO2
- Dense MCrAlY



Gas Turbine Combustion Section Components

Vanes

Ducts

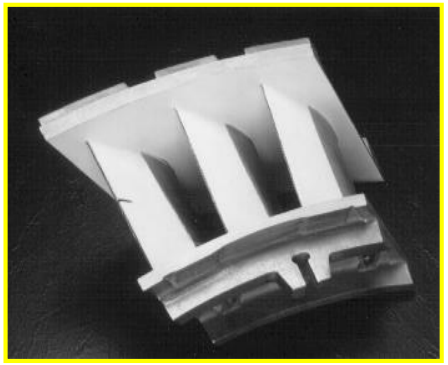
Liners

Nozzles

Combustors

Fuel Systems

Divergent & Augmenter Flaps

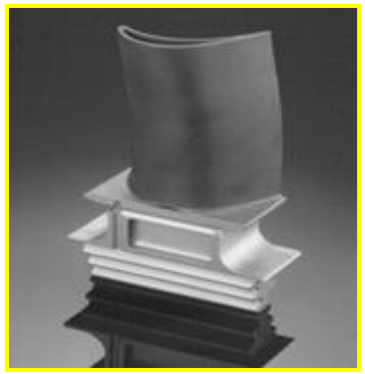


Oxidation Resistant Coatings

- **Typical MCrAlY Alloy Coatings are applied on hot-section engine components for oxidation and or hot corrosion protection**

Oxidation Control

- **Blades**
- **Buckets**
- **Shrouds**

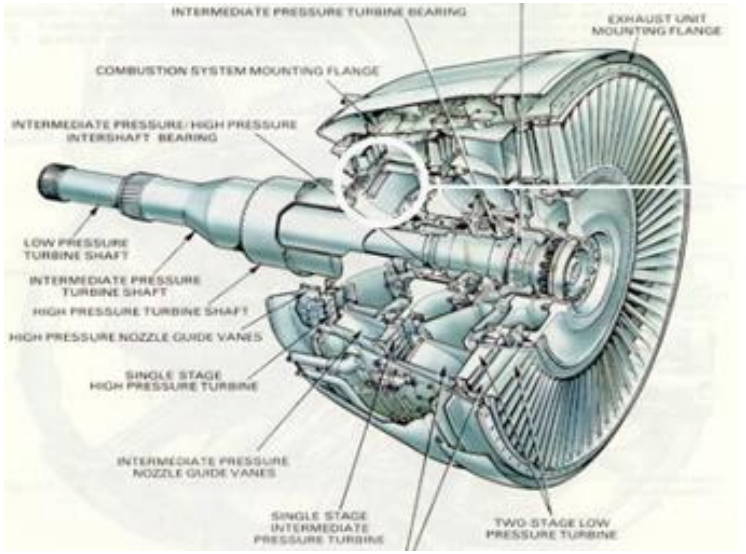


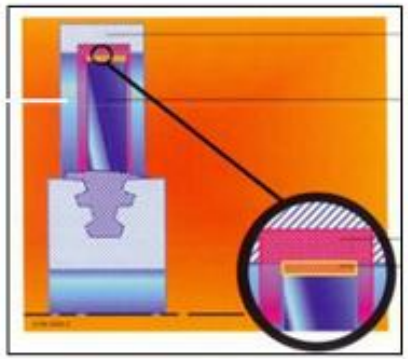
Metallic Coatings

- **Retainers**
- **‘X’ Fire Tubes**
- **Shrouds**

Seal/Clearance Control Coatings

- **Seal/abradable coatings on ring segment shrouds are used to air tightness/clearance between rotating blades and cases.**





-Ni/CoCrAlY
- Ceramic+Polymer

Wear Resistant Hardface Coatings

Wear Resistance

- LANDING GEAR
- Actuators
- TURBINE BLADES

Mid Spans, Roots, Leading Edges

- AUTO AFTERMARKET

Shifter Forks, Cylinder Bores

- PUMP PARTS

Impellors, Screws, Extruders

Coating Systems

- WC-Co
- Cr3C2-NiCr
- T800
- Mo/Mo Alloys
- Ceramics: Al2O3, Cr2O3

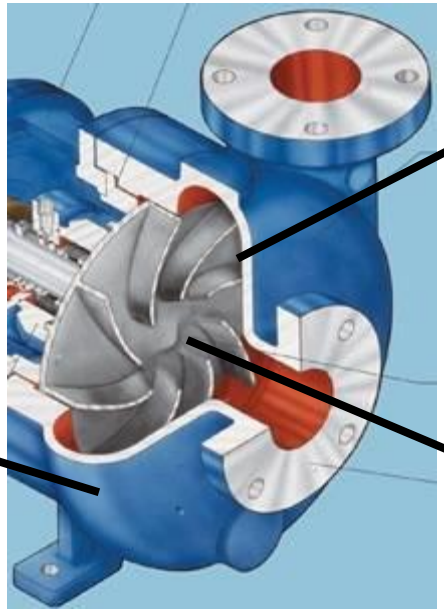
Corrosion Resistant Coatings

Oil & Gas / CHEMICAL EQUIPMENT

- Valves
- Pumps
- Stirrers

Coating System

- Stainless, NiCr Alloys
- WC-Hast Alloy
- Ceramics



Part Restoration Coatings

Part Restoration

TURBINES

- Stators, Rotors, Case, Bushings

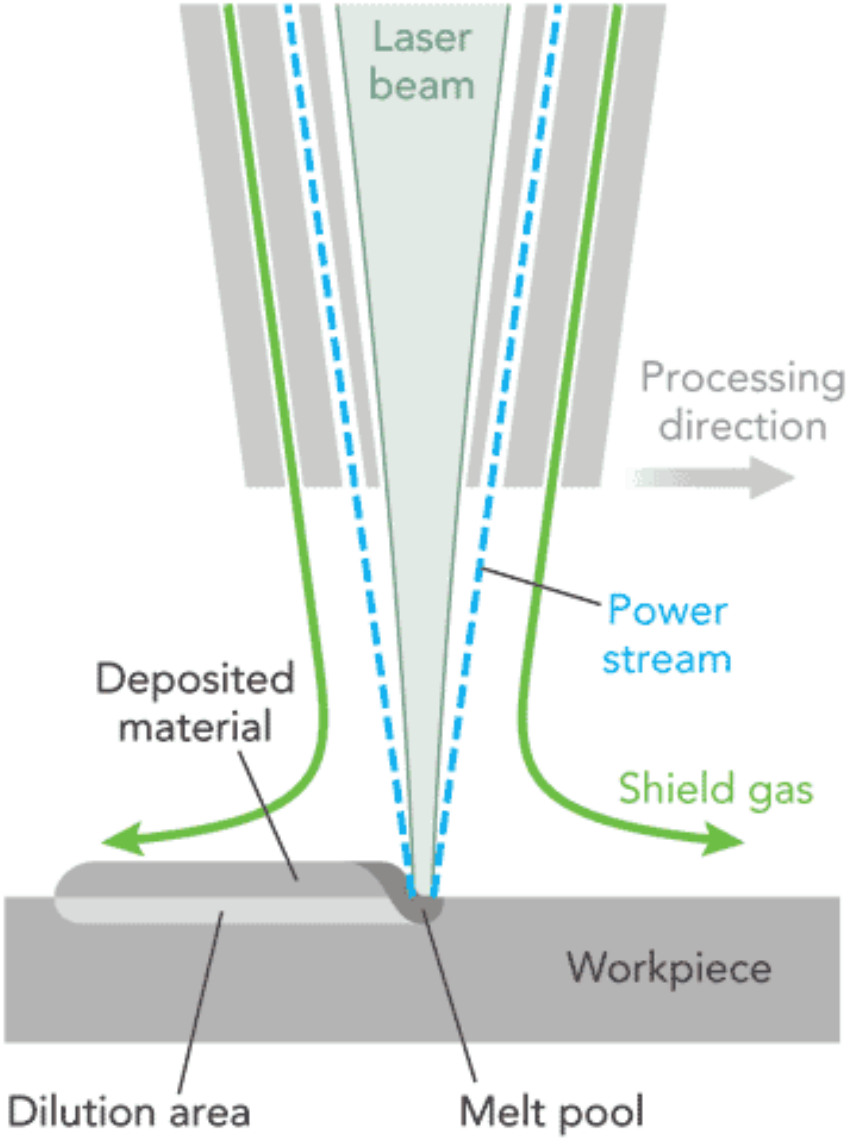
MACHINERY

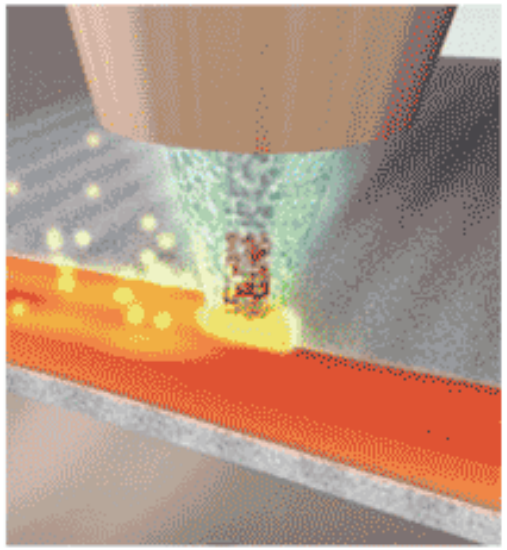
- Shafts, Housings, Bearings

Buildup Coating

- Stainless, NiCrAl Alloys
- Inconel 718

The Laser Process

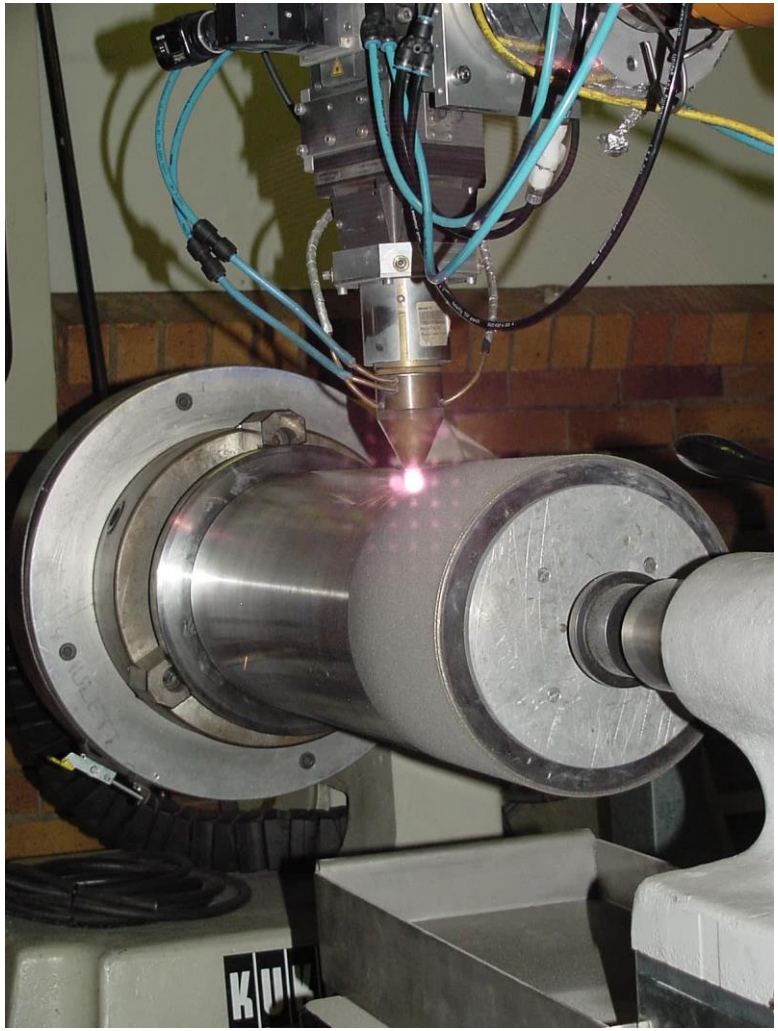




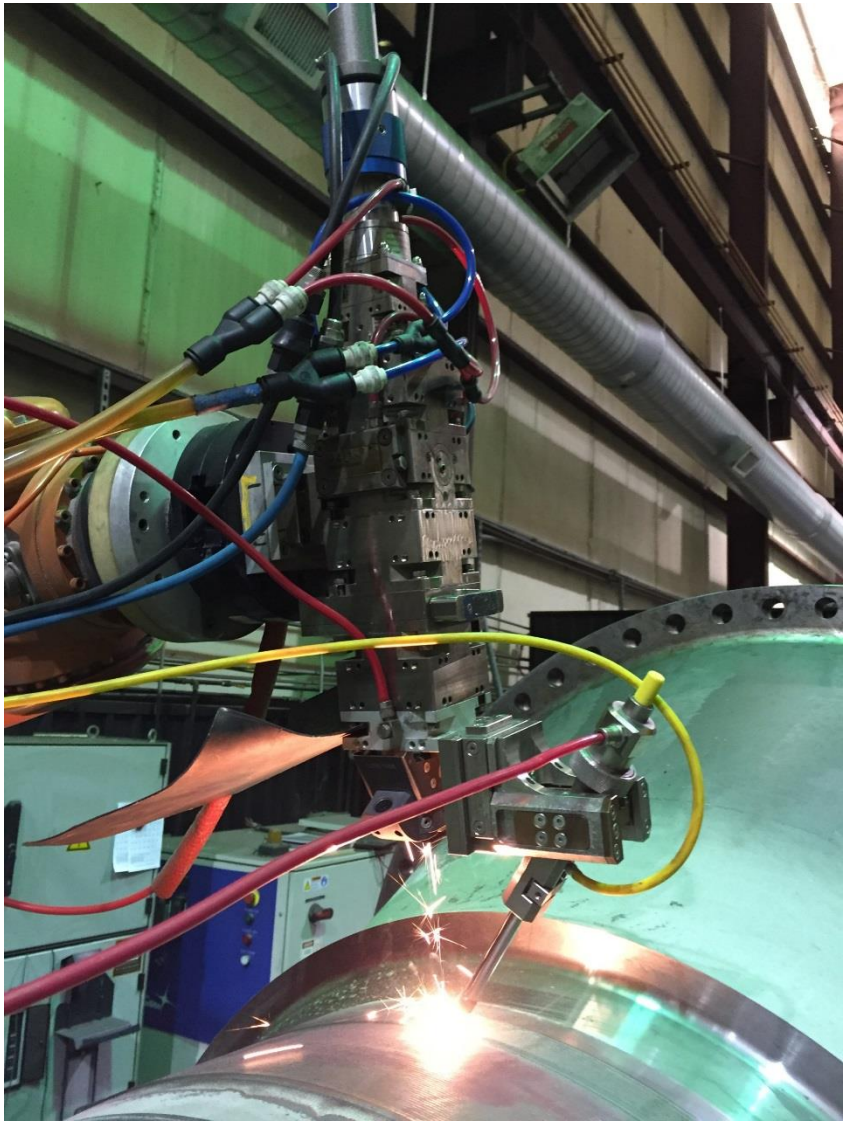
3D representation of the laser cladding process

Equipment

- Fiber delivered laser makes process practical for dusty industrial environments
- Up to 4KW of laser power with optimum beam shape and focal point
- Automated via robot for process and procedure repeatability
- Controlled feed rate for material deposition
- Optimized overlay process to produce required metallurgical properties



Laser Cladding Advantages



- Metallurgical Bond
- Low Heat Input
- Low Distortion/Warpage
- Small Heat Affected Zone (HAZ)
  - .060” [1.5mm] Typical
- Low Penetration
  - .030” [.75mm] Typical
- Low Dilution
  - 3-5% Typical

CWST Core Competencies

- Qualifications for all major Aerospace & Industrial Gas Turbine OEMs.
- Multitude of thermal spray systems supporting a broad array of coating capabilities.
- Dedicated R&D Center of Excellence.
- 7 & 8 axis intergraded robot systems for complex components.
- Engineering support for coating selection and failure analysis.
- Extensive Experience with qualification & approval processes.

Key Customer Approvals

- **Processes Are Qualified by NADCAP, ISO9001, SAE and OEMs' Specifications**

Customers	Specifications
NADCAP	Proc. Cert., Thermal spray
ISO9001	Qualify System
SAE AS9100	Qualify System
Allied Signal/Garrett (Honeywell)	EMS 52353, FP5045, GPS3227, PNCP52519, …
Allison/Rolls-Royce	EDS1306, EMS39660, …
GE-Alstom	91-328A8664
BASF	SPB-313058, 313059
Boeing	HP4-66, BAC5851, …
Dresser-Rand	PS-0321, 015-206-009
General Electric	F50TF, B50TF195,…

Customers	Specifications
UTAS Hamilton Sunstrand	HMS, HS427, HS806, …
Honeywell	A6712, M3951, P6499, …
Messier-Dowty	DCMP203
Military	NAS410, MIL-STD-1535
Pratt & Whitney	LCS, PWA35, QA-101, …
P&W Canada	CPS107, CPW693, 716, …
Rolls-Royce	EDS , EMS, & EPS Specs…
Siemens	PDS83324Z1, 83262Z3, …
Sikorsky Aircraft	SS8491, SS9212
Westinghouse	PDS8362A3, 83262AP, …

- **Data Sheets can be found at: go to www.cwst.com , Engineered Coatings; Thermal Spray Coatings and OEM Specifications, download, Tech. Articles, Sign-in, Select A Category, Thermal Spray**