

Thermal Spray Processing

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- Surface Finishers Educational Association
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Plasma Technology

- PTI founded 1969
 - supplier of plasma coatings for aircraft engines and airframes
 - 10 coatings types
- PTI today
 - Aerospace, cryogenic, marine, textile, and many more
 - > 300 coating types
 - 40,000 sq ft facility in Torrance, CA , 25,000 sq ft. facility in Windsor, CT
 - State of the art, 24 spray booths with robotics systems.
 - NADCAP certified and ITAR Registered
 - FAA & JAA approved.
 - Approved Supplier to major OEM's - Boeing, General Electric, Parker Hannifin, Pratt & Whitney, Goodrich, Bell Helicopter, Rolls Royce, Sikorsky and many others



Overview: Thermal Spray Processing

- **What is Thermal Spray**
- Applications
- Thermal Spray Techniques
- Future of thermal spray



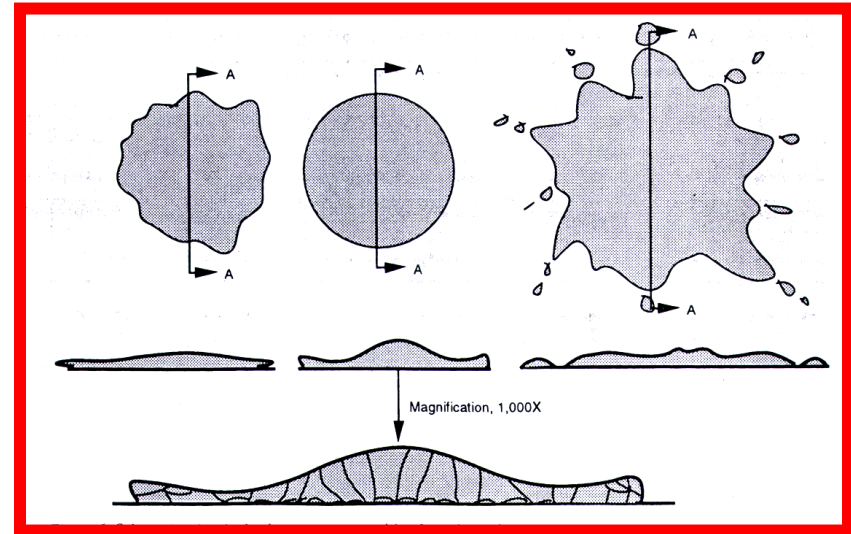
Thermal spray and ice skating: Liquification by pressure

- Thermal spray coating has similar physical mechanism as ice skating
- Pressure of skate liquifies ice
 - $\text{Pressure} = \text{force}/\text{area}$
 - Pressure of skate on water is high: weight of skater/area of blade edge
 - High pressure lowers melting point; ice liquifies, lowers friction
- Thermal spray
 - High impact speed of powder creates high pressure
 - Lowers melt temperature
 - Creates a liquid 'splat' on collision
 - Liquid flows and quickly solidifies on surface



Thermal spray basics – Splat coating

- Heated or melted materials
- Propelled by gas combustion
- May be melted by heat of impact
- Produces “splat structures”

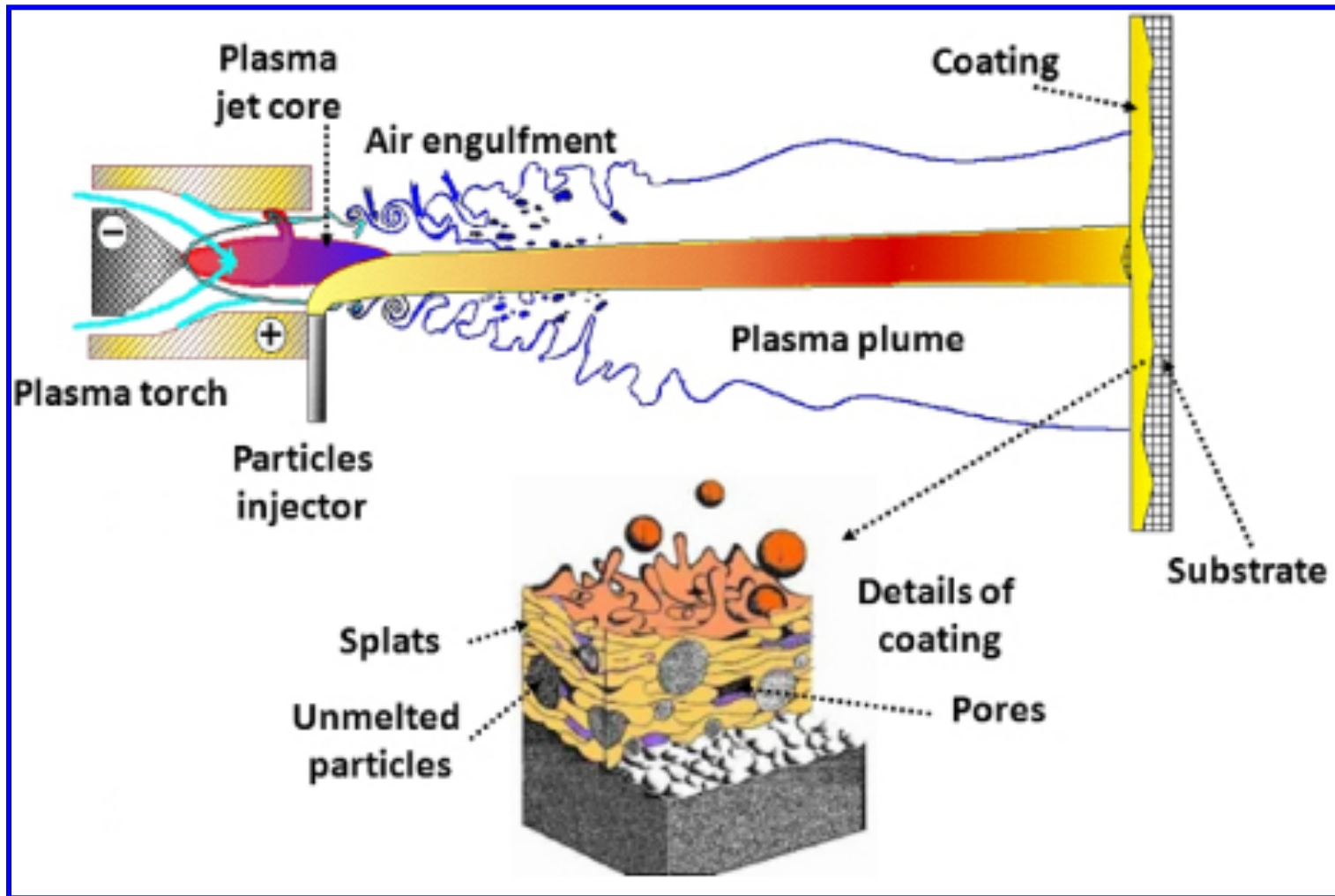


Process

- Need source of heat and feedstock
- Multiple application processes
 - Defined by temperature and velocity of particles
- Type of coating can determine process choice



Thermal Spray Process



Surface prep is crucial for quality thermal spray

- Cleaning
 - Contained perchloroethylene degreaser
 - Emits < 1 pound per year
- Grit blast
 - Roughens surface to prepare for splats



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Thermal Spray Coating Applications

- **Wear and Erosion Protection**
- **Fretting and Fatigue Wear Resistance**
- **Thermal Barrier (TB) and Multilayer TB**
- **Corrosion and Oxidation Protection**
- **Dielectric**
- **Conductive and EMI Shielding**
- **Lubricious – low friction, low wear**
- **Metal and Alloy Build-up for Overhaul of Worn Components**



Thermal Spray: Ocean floor → Mars

Industry	Chrome Carbide	Self-Fluxing	Iron and Steel	Nickel Alloys	Super-alloys	MCrAlY	Tungsten Carbide	Non-Ferrous
Aero Gas Turbine	x		x	x	x	x	x	x
Stationary Gas Turbine	x		x	x	x	x	x	x
Hydro-Steam Turbine	x	x	x	x	x		x	x
Automotive Engines	x			x	x	x	x	
Diesel Engines	x		x	x	x	x	x	
Railroad		x	x	x				x
Steel Rolling Mills		x	x	x	x		x	x
Forging		x	x	x	x		x	
Ship and Boat Manufacture/Repair			x	x				x
Cement and Clay		x	x					x
Chemical Processing			x	x	x		x	
Rubber and Plastic Manufacture		x	x	x			x	
Textile			x					
Food Processing		x	x					
Pulp and Paper		x	x	x				
Printing Equipment								x
Glass Manufacture	x	x	x					



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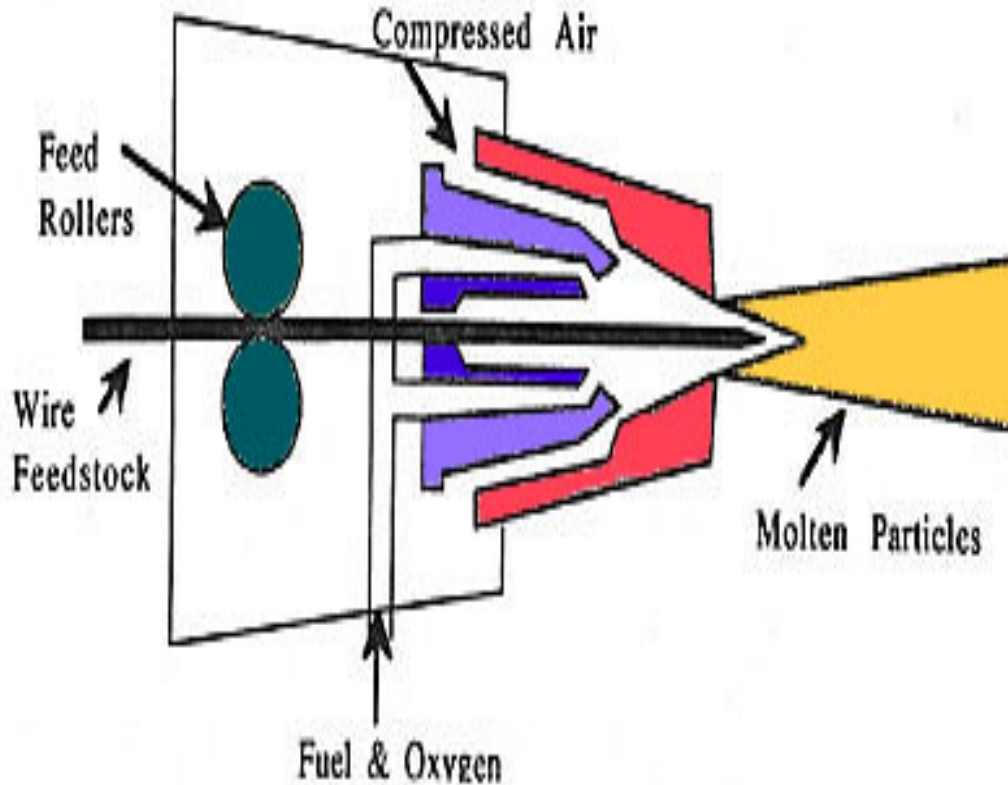


Thermal spray techniques

- **Powder flame spray or *combustion* (lower melting materials)**
- Wire flame spray or *combustion* (lower melting materials)
- **Plasma (almost any material)**
- LPPS (Low Pressure Plasma)
- **HVOF (High Velocity combustion)**
- Wire spray (wire consumable)
- Axial Plasma (High deposit efficiency)
- Cold Spray



Flame Spray

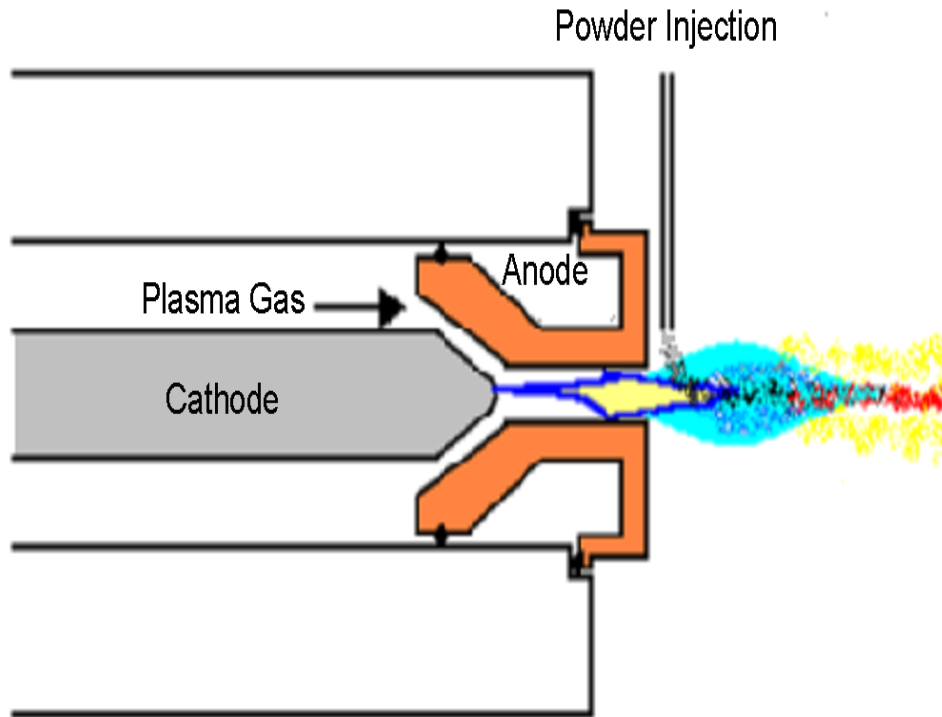


Characteristics

- Flame Temperature
 - 4,000 – 5,000 °F
 - (2,200 – 2,760 °C)
- Fuel Used (O₂ mixed)
 - Acetylene
 - Propane
- Particle Speed
 - 200 – 800 ft/s
 - (60 – 240 m/s)



Plasma Spray

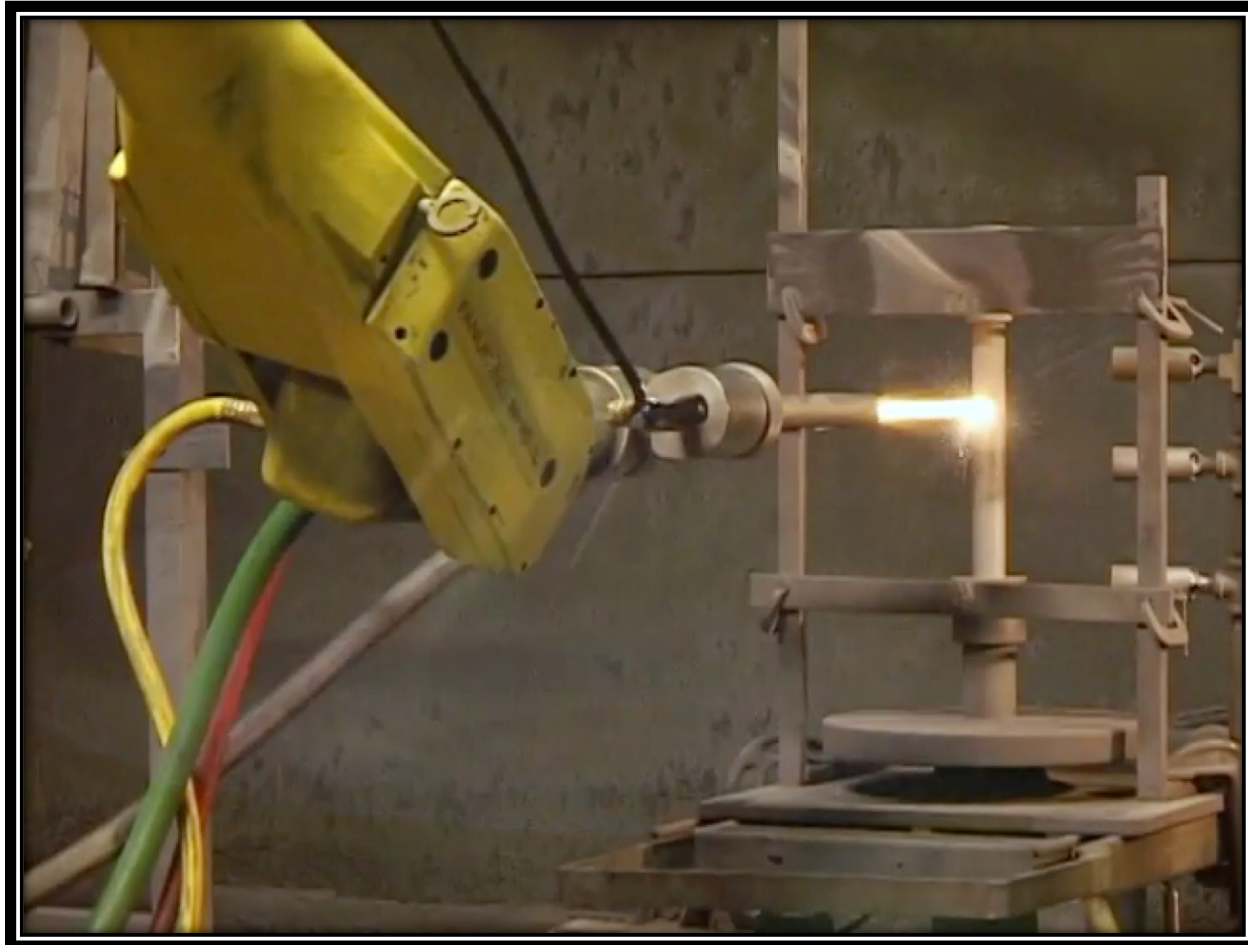


Characteristics

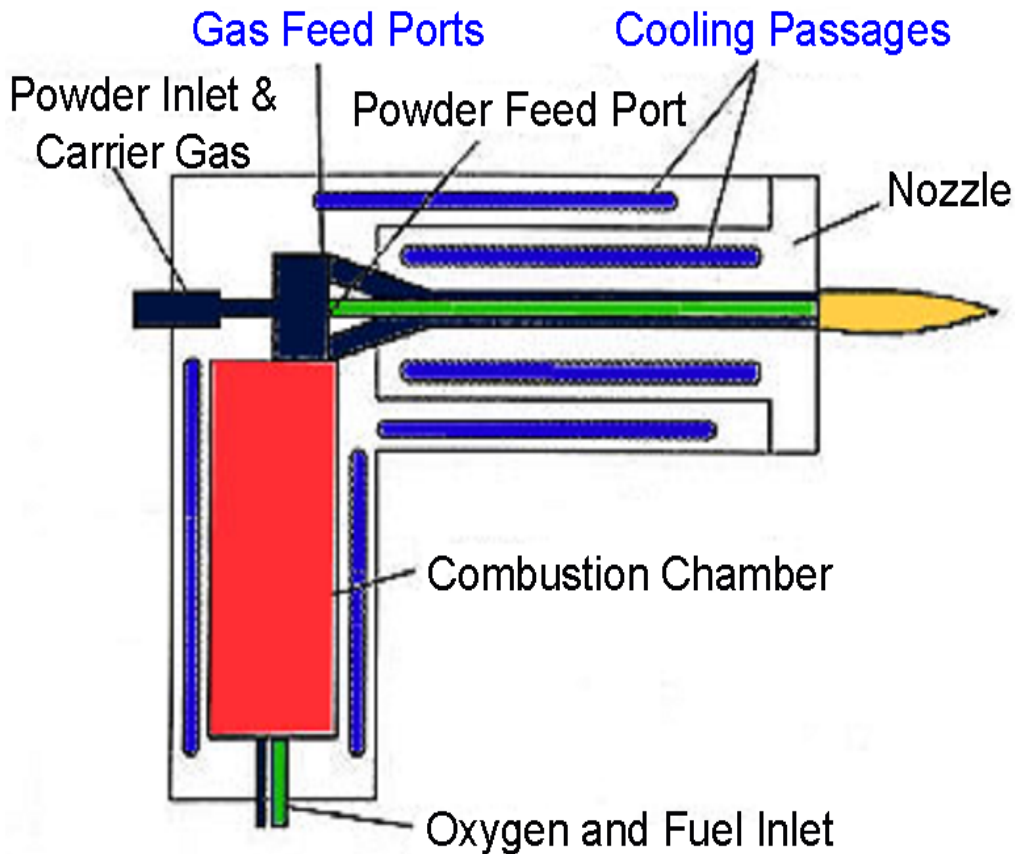
- **Flame Temperature**
 - 12,000 – 20,000 °F
 - (6,000 – 11,100 °C)
- **Gases Used**
 - Ar/H₂
 - N₂/H₂
 - Ar/He
- **Particle Speed**
 - 800 – 1,800 ft/s
 - (240 – 550 m/s)



Plasma Spray



High Velocity Oxy-Fuel (HVOF)

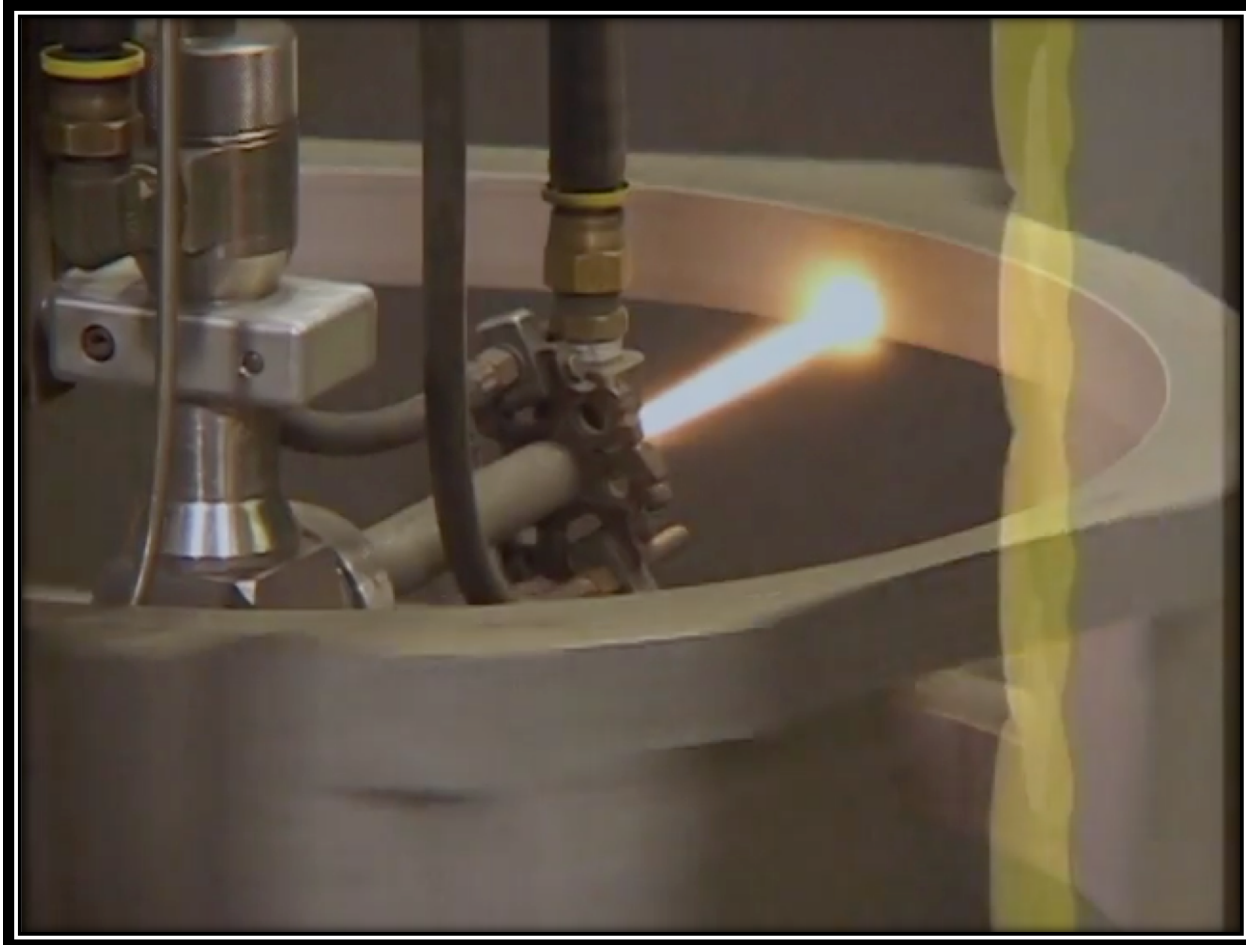


Characteristics

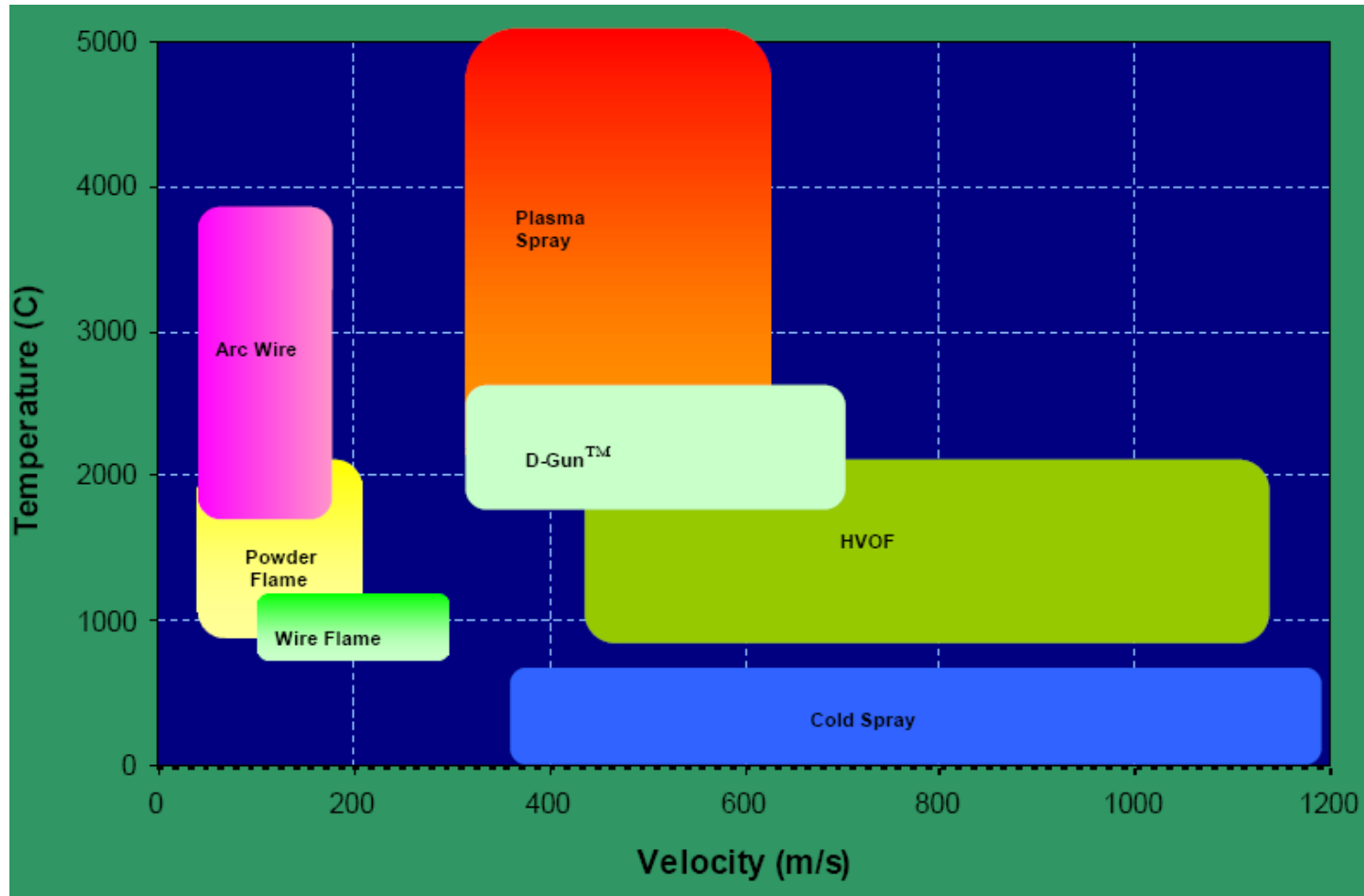
- **Flame Temperature**
 - 5,000 °F
 - (2,760 °C)
- **Fuel Gases**
 - Propylene
 - Propane
 - Hydrogen
- **Particle Speed**
 - 4,500 ft/s
 - (1,400 m/s)



HVOF



Temperature-Velocity Characteristics



Plating and Thermal Spray Comparison

Plating

- Liquid
- Immersion tanks
- Electrochemical/electroless
- Fixed location
- Bond strength ~3000psi
- “Smooths” surface irregularities

Thermal Spray

- Powder
- Line of sight, spray booths
- Mechanical
- Portable options
- Bond strength ~10000 psi
 - e.g. Tungsten carbide
- Conforms to surface microprofile



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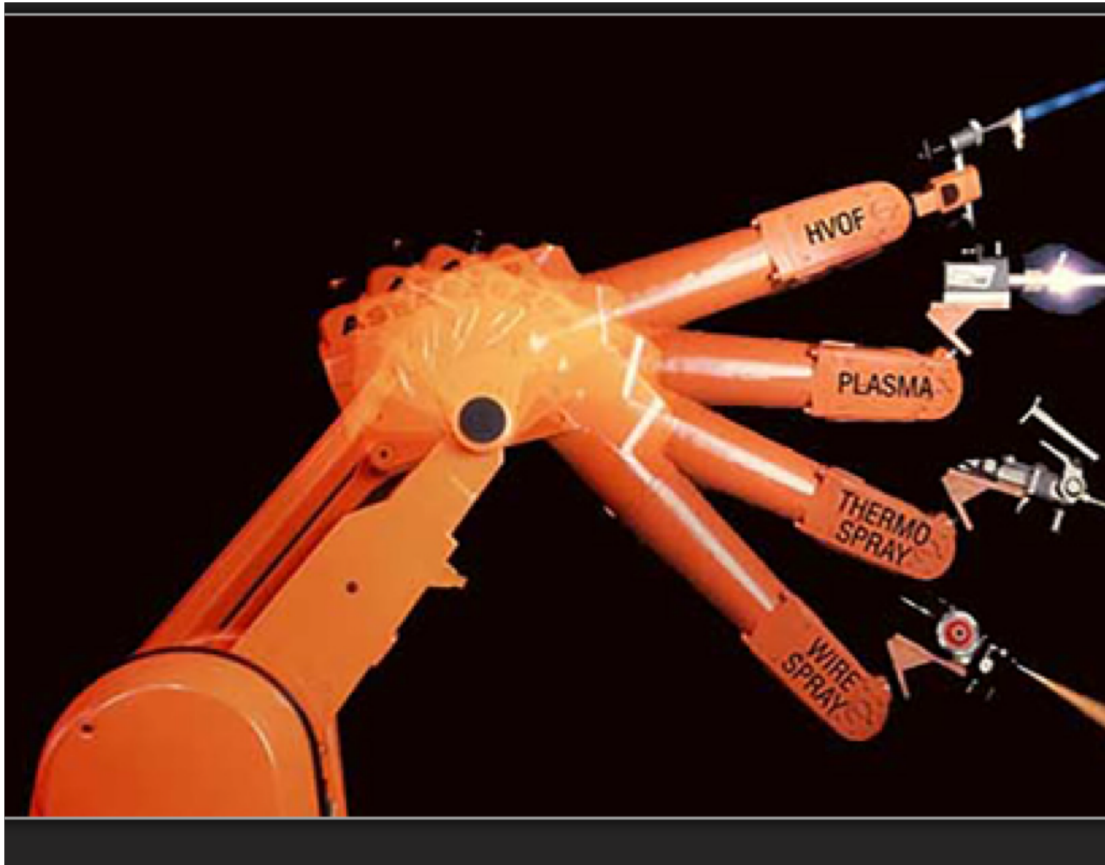
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Future of Thermal Spray

- Architecture
 - Temperature control
 - Energy saving
 - Decorative (e.g. reflective glass)
- Deep water applications
 - Deep Horizon event: valve failed due to corrosion
 - Thermal spray coatings can last to 100 years
- Low efficiency solar panels
 - Alloys to make low cost panels for windows, walls and roofs





Questions??

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