An Introduction To Thermal Spraying And Its Applications
What Is Thermal Spraying?

- It is a process for applying coating onto a solid substrate.
- Thermal sprayed coatings are melted, or softened metallic, ceramic, or polymer materials which are transported by a gas stream to a substrate.
- Thermal spray is NOT a welding process.
What Can We Do With Thermal Spray?

- Improve/ change the surface of a material
- Repair and refurbish worn components
- Provide corrosion protection
History of the Process

- Pioneered by Dr M U Schoop of Zurich in the early 1900’s (1st patent 1909)
- Started out by pouring molten metal into a high pressure gas stream
- Developed to depositing coatings from solid wires
- Introduced in the UK in 1922 (foundation year of Metallisation)
Introduction to Thermal Spraying
What Are Thermal Sprayed Coatings?

These coatings are typically mechanically bonded to a grit blasted surface.

The coatings are similar to the metals being sprayed, however there are some important differences:

1. Particles in the coating create a layered effect within the coating structure.

2. Due to the rapid cooling of the metal particles as they adhere to the substrates, thermal sprayed coatings have unique crystalline structures not normally found in wrought metals.

3. There are oxide stringers and porosity in the coatings.

Almost any material can be thermal sprayed onto almost any substrate.
Metal spraying

Four common processes:

- Flamespray
- Arcspray
- Plasma
- HVOF
Typical Arc Sprayed Coating

- Metallisation Arc 140
- Material 60E 13% chrome steel
- Hardness 35 Rc
- Porosity 3%

100 microns coating thickness
Typical HVOF Sprayed Coating

- Metjet-4L liquid fuel
- Material WC/Co/Cr
- 86/10/4
- Hardness 1360 HV 300
- Porosity 0.1 %

100 microns coating thickness
Thermal spray highlights

- **Instant curing**
  - No drying or curing time – can be handled straight after application

- **Metallurgically cold process**
  - Virtually no heat input to the substrate (<80°C typically). No distortion.

- **Typically mechanical bonding process**
  - Normally requires grit blasting (sometimes m/c’ing or preheat)

- **Can spray many materials**
  - Zn / Al / Cu / Steels / Bronzes / Ceramics / WC / Mo/ Abradables/ Thermal Barriers etc.

- **Can be applied at various thicknesses**
  - Typically 150-750 microns but can be more

- **Line of sight process**
ARC SPRAY

Electric Wire Arc is a cost effective method of applying a wide range of metallic coatings and alloys including

Aluminium
Steels
Stainless steels
Nickel
Copper
Zinc
Bronze
An electric arc is struck between 2 wires
The wires melt
The resultant melted particles are atomised by compressed air
Compressed air projects particles
Arcspray Equipment

Metallisation Arc140
- Lightweight pistol
- 5-20m wire drive (push/pull)
- Throughput
  - 8.5 kg/hr (2.3mm Al)
- Deposit efficiency
  - 65% (Al)
- Typical bond strength
  - 13.75MPa (Al)
Flamespray process

- Oxygen / Propane flame melts wire
- Compressed air projects particles
Flamespray Equipment

- Metallisation MK73
  - Hand held pistol
  - Oxy-propane flame
  - Stop/start function
  - Up to 80m hose length
  - Throughput
    - 7.5 kg/hr (3/16” Al)
  - Deposit efficiency
    - 85% (Al)
  - Typical bond strength
    - 6 MPa approx. (Al)
Typical Plasma Applications

- Typical applications
  - Gas turbine parts
  - Print industry rolls
  - Aerospace components
  - Seal areas
  - Thermal barrier coatings
Plasmaspray process

- Plasma jet created by arcing in plasma gas
- Ceramic / metal powder injected into plasma stream
- Particles soften and strike surface at high velocity
NEW PS50M-PC Controlled System

- Metallisation PS50M-PC
- PC / Touch screen control
- Powder feeder
- 50kW Plasma system
- Mass flow control (repeatability and quality coatings)
**Typical HVOF Applications**

- Typical applications
  - Hard chrome replacement
  - Ball/Gate valves  oil industry
  - Suspension components
  - Automotive valves
  - Aerospace landing gear
HVOF process

- Oxygen / liquid fuel (kerosene) ignites in chamber
- Combustion gases accelerated through nozzle (Mach 2+)
- Powder injected into gas stream
- Particles soften and impact substrate at high velocity
MET-JET 4L System

- Metallisation MET-JET 4L (Liquid)
  - PC / Touch screen control
  - Clean burn / simple nozzle
  - Rotating disc Powder feeder
  - Oxy/Kerosene system (high density, thick coatings)
  - Mass flow control (repeatability and quality coatings)
Anti-corrosion

Burj Al Arab Hotel, Dubai. TSA 10,000m² 150µm
Anti corrosion

Vessels and Pipework (internal TSA), Gas Plant, UAE
Anti-corrosion

Concrete bridge sprayed to give galvanic protection to reinforcing bars
Forth Road bridge sprayed by Metallisation 1963. Original zinc still excellent and being re-painted.
Anti Corrosion. Moana III

Being Arc Sprayed on a blasted SA3 surface with Zinc at 100µm using Metallisation Arc Spray 234 system

After more than 20 years, the vessel has been repainted on the hull, but no corrosion is apparent in areas where the Zinc Arc Spray was applied.
Anti-corrosion.

Automated LPG bottle coating, Luxembourg. Twin Arc 528 pistols
Tungsten Carbide Cobalt
Extreme Hardness
HVOF Sprayed
To Diverter Valve
Body Internals.
Print, Packaging & Paper

- Ink Rollers, Copper, Ceramic, Steel
- Ceramic Anilox Rollers
- Anvil Cylinders
- Litho Cylinders
- Path Rollers
- Feed Rollers
- Yankee Dryers
- Chrome Replacement

Repair
Refurbish
OEM
HVOF Sprayed NiCrBSi Water Cooled Print Roll
Offset Litho Print Cylinders
Refurbished in Arc Sprayed
60E 13% Chrome Steel

After

Before
HVOF Sprayed NiCrBSi Web Printing Cylinder
Arc/ HVOF Combined Coating on Traction Infeed Roll
Blast Furnace Fan

Blade Leading Edges
HVOV Tungsten Carbide Coated
Oil & Gas

Extreme Hardness Coatings On Down Hole Tooling, Valves, Sensors.

Anti-corrosion Coatings On Offshore Structures
Marathon Brae B, flare boom, jacket, cellar decks all sprayed with aluminium.

All flare booms and almost all jackets and cellar decks in North Sea are sprayed
Chistmas Tree Of Gate Valves

Most Gate Valves Use Carbide Coatings to Resist abrasive Wear, Corrosion, Heat And Pressures Up To 30,000 p.si.
HVOF Carbide Coated Ball & Gate Valves
Rock Drilling Bit HVOF Tungsten Carbide Coated
Aluminium Sand Drilling Bit For HVOF Tungsten Carbide Coating
Oil & Gas Riser Pipes
Anti-corrosion & HVOF Carbides
Motorsport
Thermal Barrier Coatings
Plasma Sprayed
Aerospace

Engines
Landing gear
Controls
Gas Turbine.
Extensive use of Plasma Sprayed Thermal Barrier Coatings & Abradables
Aircraft Landing Gear
Hard Chrome Replacement. Carbides or NiCrBSi HVOF Sprayed
Hard Chrome Replacement. Carbides or NiCrBSi HVOF Sprayed
Hard Chrome Replacement. Carbides or NiCrBSi HVOF Sprayed

Hydraulic Ram Piston Rod
Hard Chrome Replacement. Carbides or NiCrBSi HVOF Sprayed

Mining Hydraulic Pit Props
Medical Implants

Plasma sprayed coatings of hydroxyapatite are often applied to metallic implants to alter the surface properties.

The body sees hydroxyapatite-type material which it is happy to accept.
<table>
<thead>
<tr>
<th>PROCESS</th>
<th>TEMP ºC</th>
<th>PARTICLE VELOCITY m/s</th>
<th>BOND STRENGTH MPa</th>
<th>POROSITY %</th>
<th>TYPICAL MATERIALS SPRAYED</th>
<th>TYPICAL APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire flame spray</td>
<td>3000</td>
<td>50-100</td>
<td>5-27</td>
<td>10-15</td>
<td>Aluminium Zinc Molybdenum Other Metals</td>
<td>Anti-corrosion coatings</td>
</tr>
<tr>
<td>Arc Wire</td>
<td>4000</td>
<td>50-100</td>
<td>14-50</td>
<td>10-15</td>
<td>Aluminium Zinc Engineering metals</td>
<td>Anti-corrosion coatings, Engineering reclamation</td>
</tr>
<tr>
<td>Powder flame spray</td>
<td>3000</td>
<td>20-50</td>
<td>14-34</td>
<td>5-15</td>
<td>Metals Ceramics Carbides</td>
<td>Engineering reclamation, Jobbing work</td>
</tr>
<tr>
<td>Plasma</td>
<td>15000</td>
<td>50-150</td>
<td>34-68</td>
<td>&lt;1-5</td>
<td>Ceramics TBCs Metals Abradables</td>
<td>Aerospace, gas turbines, medical implants, print rollers, thermal barrier coatings</td>
</tr>
<tr>
<td>HVOF</td>
<td>2500</td>
<td>300-700</td>
<td>41-95</td>
<td>&lt;1</td>
<td>Carbides Metals</td>
<td>Oil &amp; gas industry components, extreme wear applications, hard chrome replacement, aircraft landing gear</td>
</tr>
</tbody>
</table>
Quick quiz – is thermal spray a hot or cold process?

- Test piece
  - 1 x tech service engineer
  - Coating – flame sprayed aluminium

Don’t try this at home – just for demonstration purposes only
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