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Kermetico High Velocity Air-Fuel Thermal Spray

HVAF application development

1. Superior hard & tough coatings for new markets

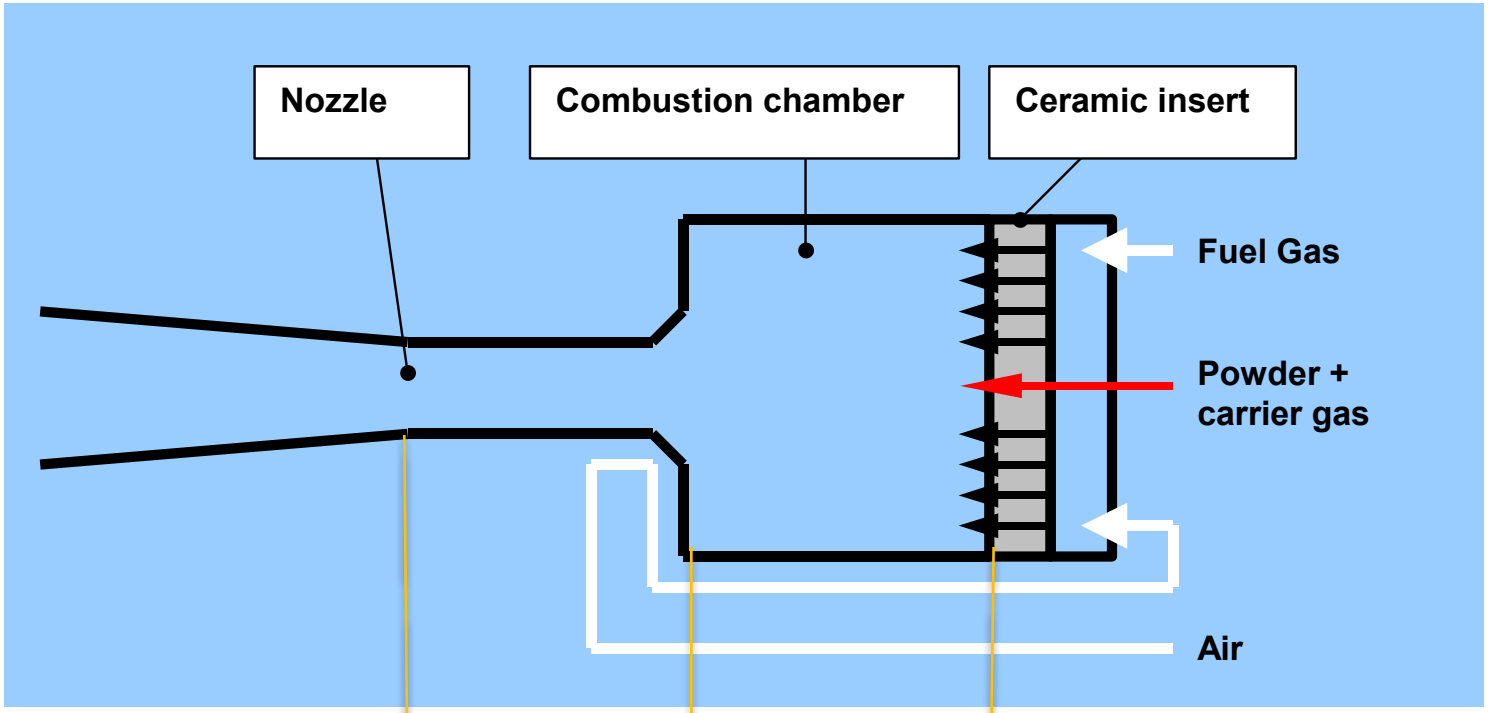
- Gas-tight
- WC-based 1500-1700 HV_{300}
- Cr_3C_2-based 1100 HV_{300}, service up to 900°C
- MoB-based 1200 HV_{300}, service up to 1100°C
- Thin coatings (40-70 micron) for:
  High and alternating stress, impact, etc.
  Economy grades for “flash chrome” replacement

HVAF application development

2. Economical “currently specified quality” coatings for existing and new markets

1200 HV_{300} /<0.8% porosity WC-coatings, sprayed at 65-70% DE with spray rates 33+ kg/hour

Kermetico HVAF gun design



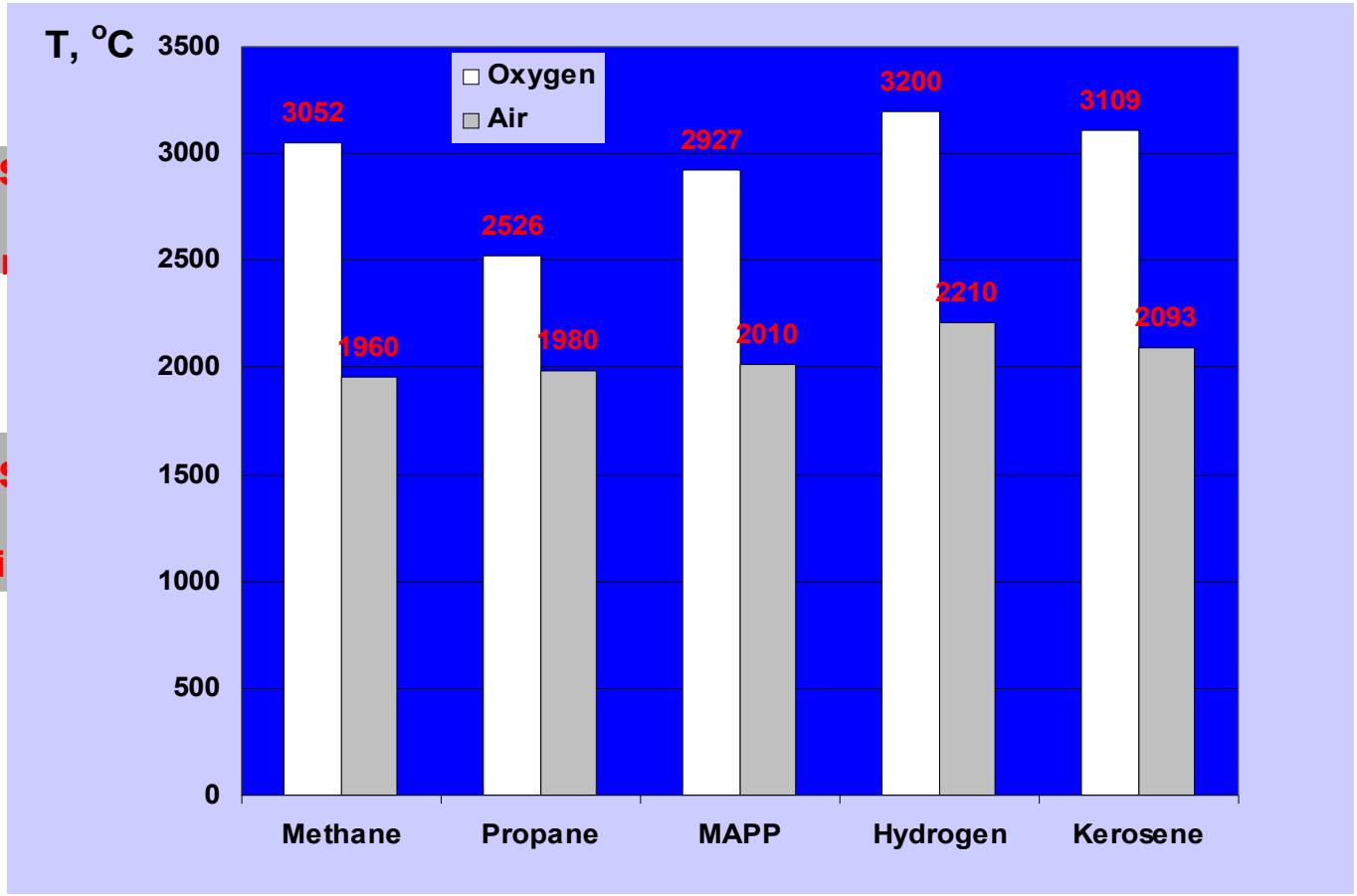
1100-1500 m/s	850 m/s	40-50 m/s	Gas velocity
<1500°C	~1600°C	1900°C	Gas temperature
Acceleration		Heating	Spray particle

Combustion temperature: HVAF vs. HVOF

Adiabatic combustion temperature of fuels in oxygen and air (α=1, 20°C, 1 Bar)

Metals
T boili

Metals
T melti



Lower gas temperature in HVAF:

HVOF:

Combustion temperature is higher by more than 1000^{o}C than melting temperature of metals;

Combustion temperature may exceed metal boiling temperature.

HVAF:

Combustion temperature only slightly higher than metal melting temperature.

Lower gas temperature in HVAF:

- **Affects coating properties**

Prevention of oxidation of metals and oxidation/ thermal deterioration of carbides

Note: oxygen activity is 5-times lower in HVAF

- **Influences gun design**

HVAF ability to use heating in long/ slow-gas combustion chambers = long time for "soft" heating

High pressure in the chamber = better heat transfer

Combustion temperature: design AF vs OF

Ability to use heating in long/ slow-gas combustion chambers =

long time for “soft” heating

High pressure in the chamber =

better heat transfer

Result:

High energy efficiency of HVAF

(same or lower power while higher spray rates than HVOF)

Energy efficiency = COST

State-of-the-art HVOF:

JP 5000 270 kW spray rate 5 kg/hour

DJ 2600115 kW spray rate 4 kg/hour

Kermetico HVAF:

AK6 130 kW spray rate 28 kg/ hour

AK5 80 kW spray rate 15 kg/hour

AK-ID 30 kW spray rate 5 kg/hour

Acceleration of spray particles in the nozzle:

- **Gas velocity & density**
- **Time (nozzle length)**
- **Particle size**

Smaller particles are accelerated to higher velocities.

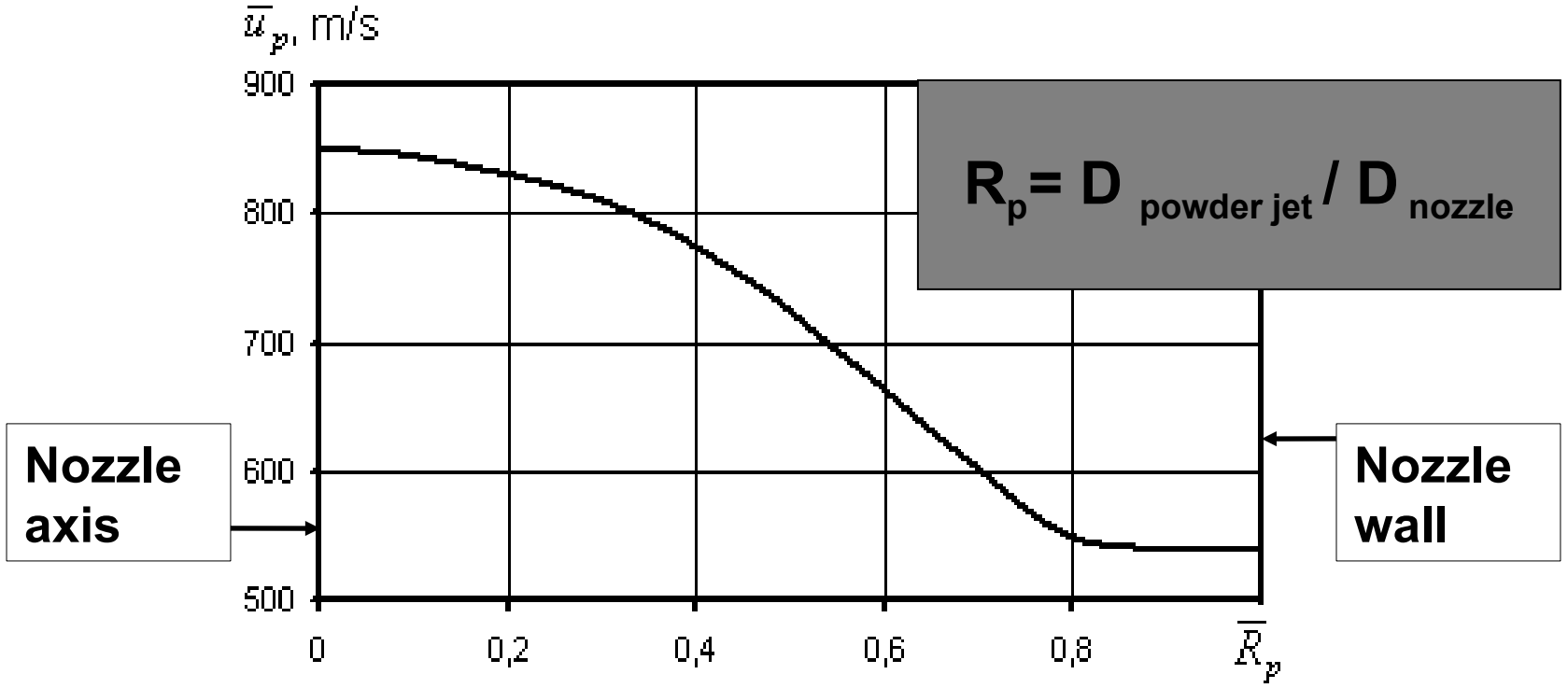
HVAF uses smaller particle size without material oxidation/ thermal deterioration

Note on nozzle wall influence on particle velocity:

- **HVOF – dramatic**
  - **(more so – in radial injection)**
- **HVAF – no influence**

Particles acceleration: influence of the nozzle walls

HVOF (kerosene) per A. Voronetsky et. all, ITSC2004



Influence of R_p on the mean particles velocity at L_S=250 mm. (p_{cc} =0.9 MPa, d_p=30 μm, L_b=100 mm)

Particles acceleration in the nozzle

Kermetico HVAF:

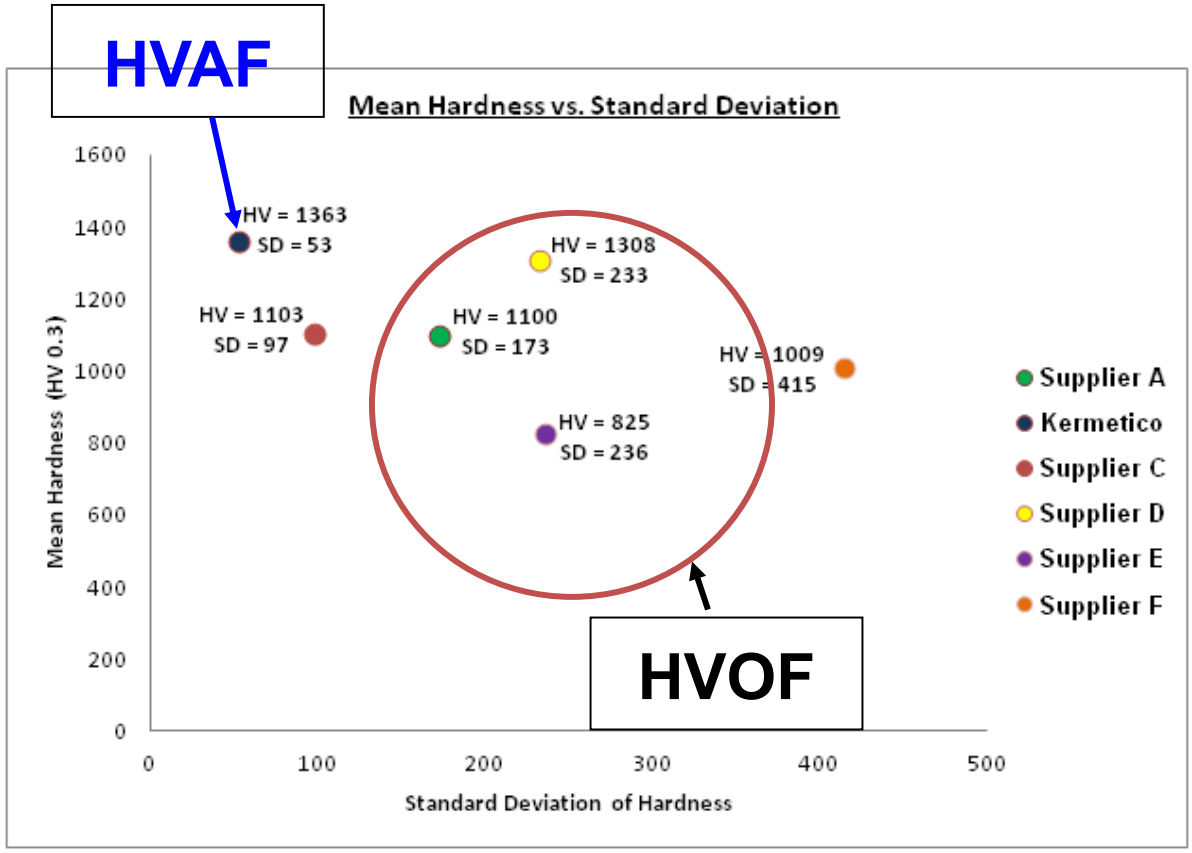
$$D_{\text{powder jet}} / D_{\text{nozzle}} = 0.1\text{-}0.2$$

I. There is practically no restriction on the nozzle length to reach necessary acceleration of spray particles

II. Uniform acceleration = uniform coating structure and properties

Uniformity of HVAF coatings properties:

Hardness of HVOF and Kermetico HVAF WC-10Co-4Cr coatings (Schlumberger, UK)



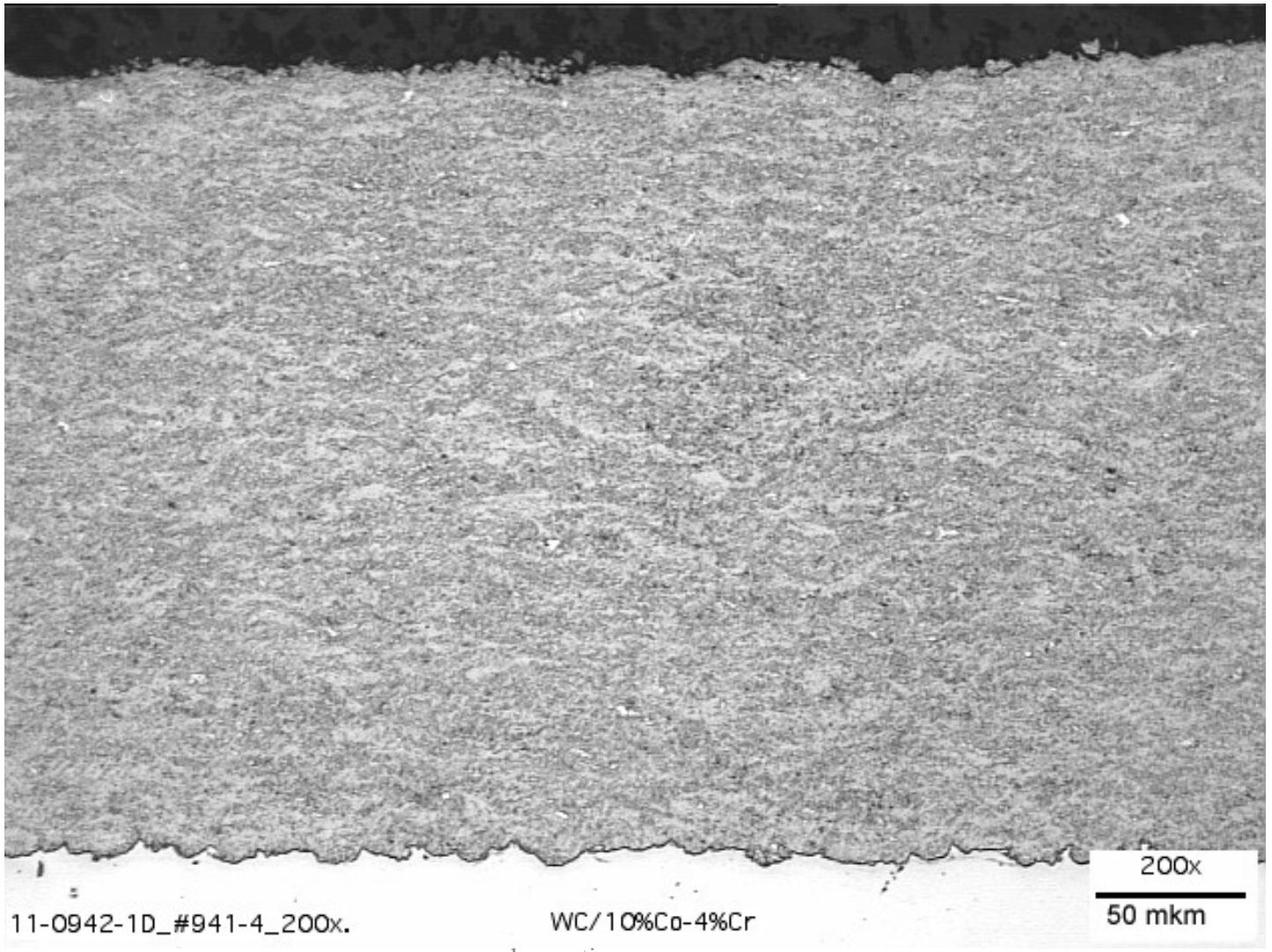
Relative standard deviation, %

HVAF: 3.9 %

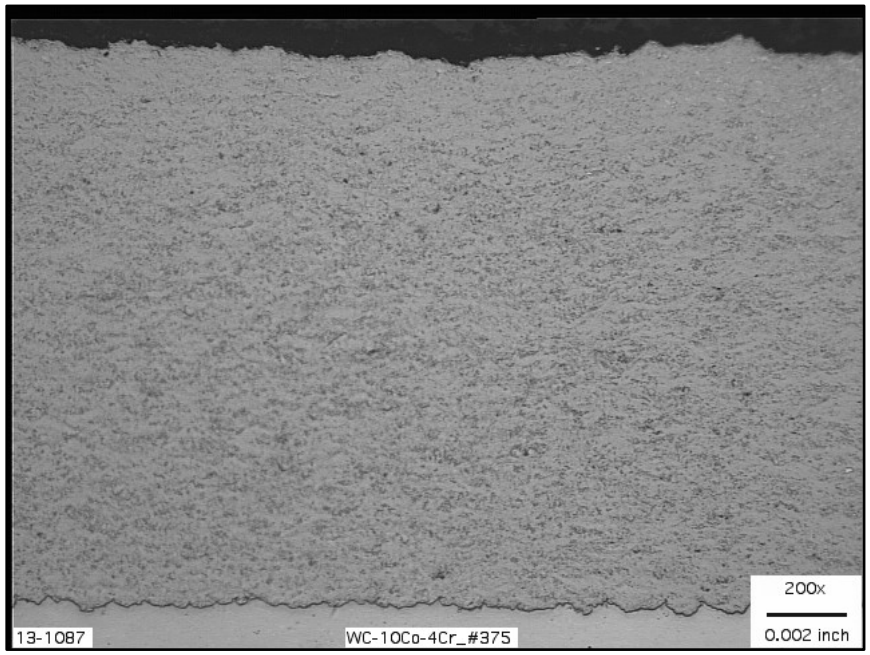
HVOF: 15.7-17.8%

WC-10Co-4Cr coating characterization

Propane
1470 HV_{300}



WC-10Co-4Cr coating characterization

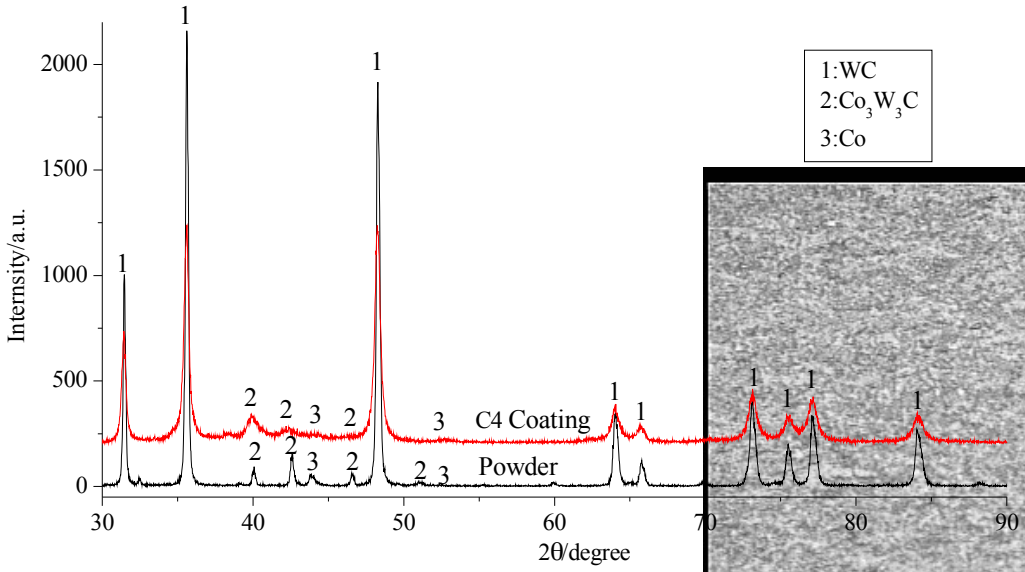


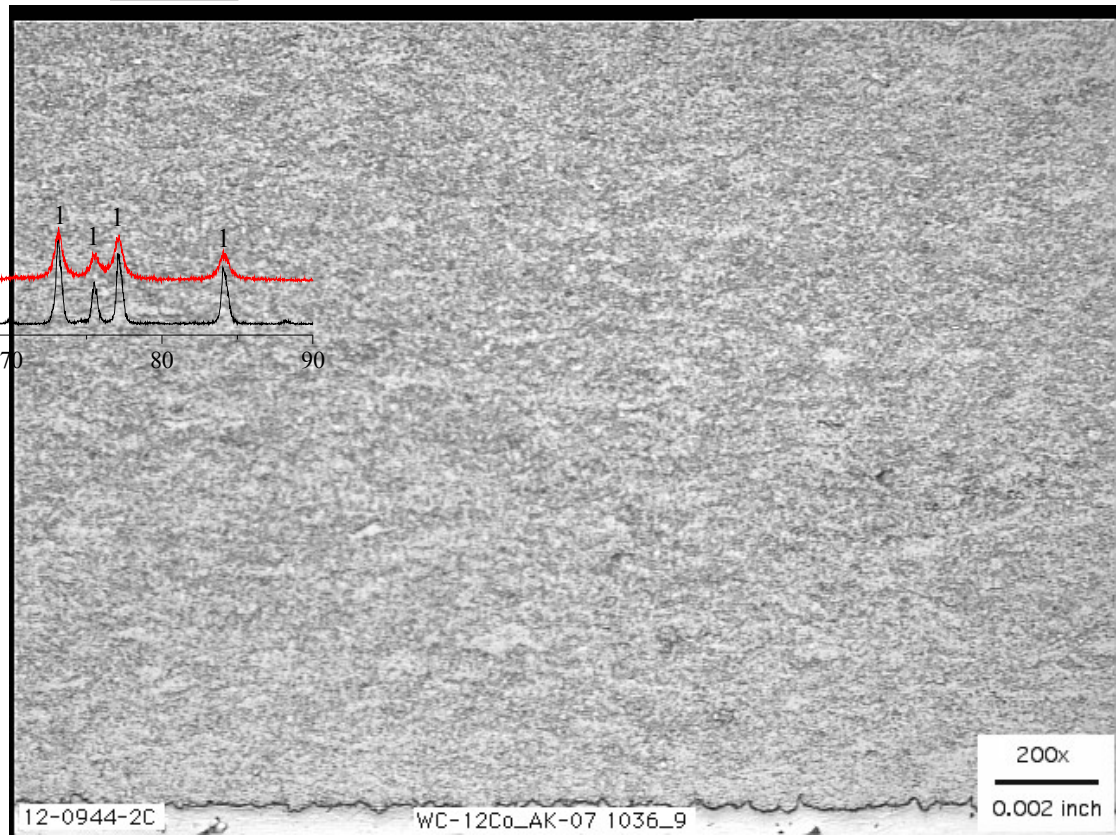
Propane- 60% Butane
1500 HV_{300}

Propylene
1650 HV_{300}

Kermetico HVAF:

Carbides hard, but… ductile





WC-12Co
Propane
1540 HV300

Data of Central Power Research Institute Bangalore, India

Comparison of WC-10Co-4Cr coatings, deposited with HVOF (JP5000) and Kermetico HVAF (AK06)

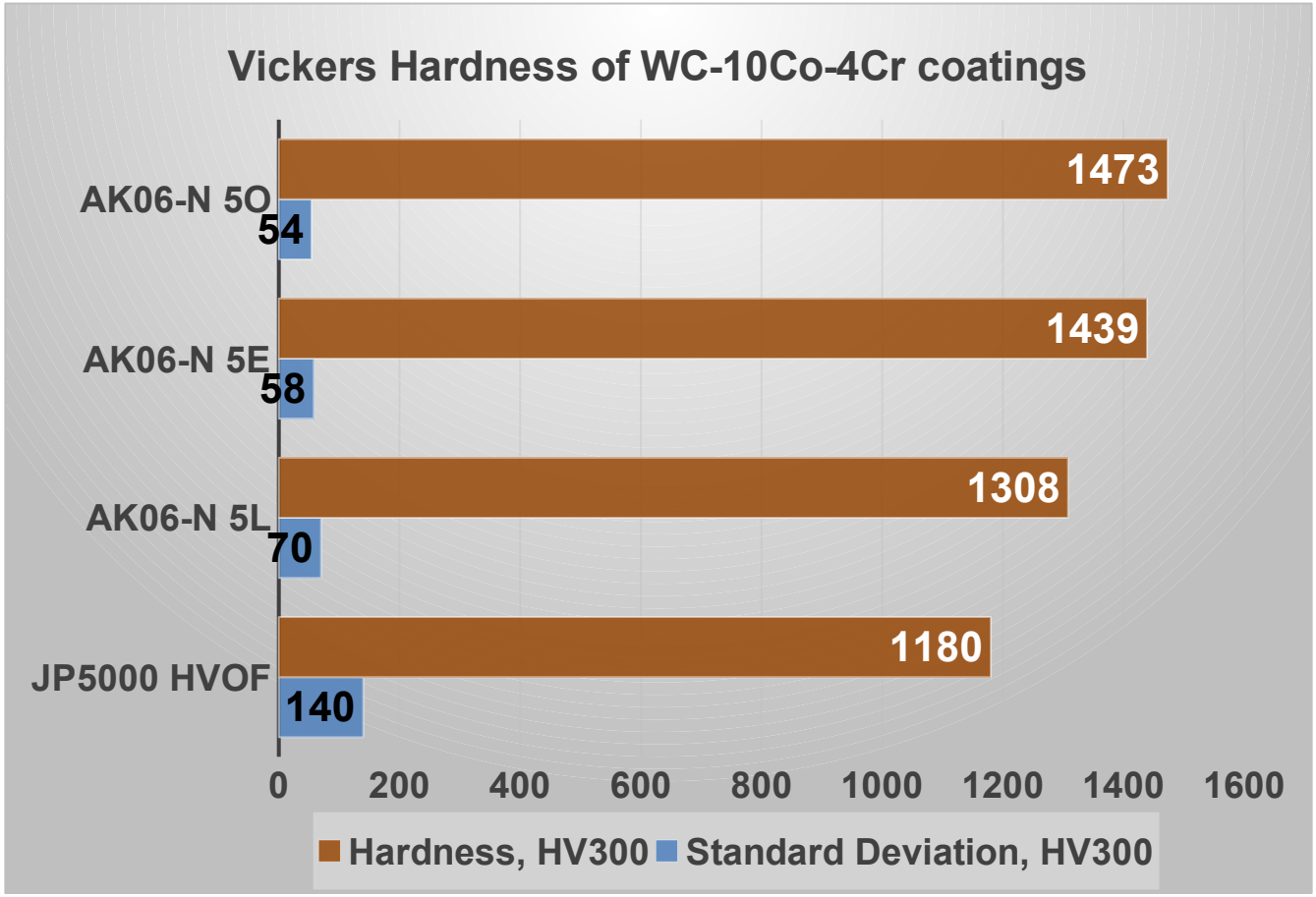
Notes:
HVOF optimized for the best cavitation resistance

HVAF applied in different modes, targeting different particle velocity (coating hardness)

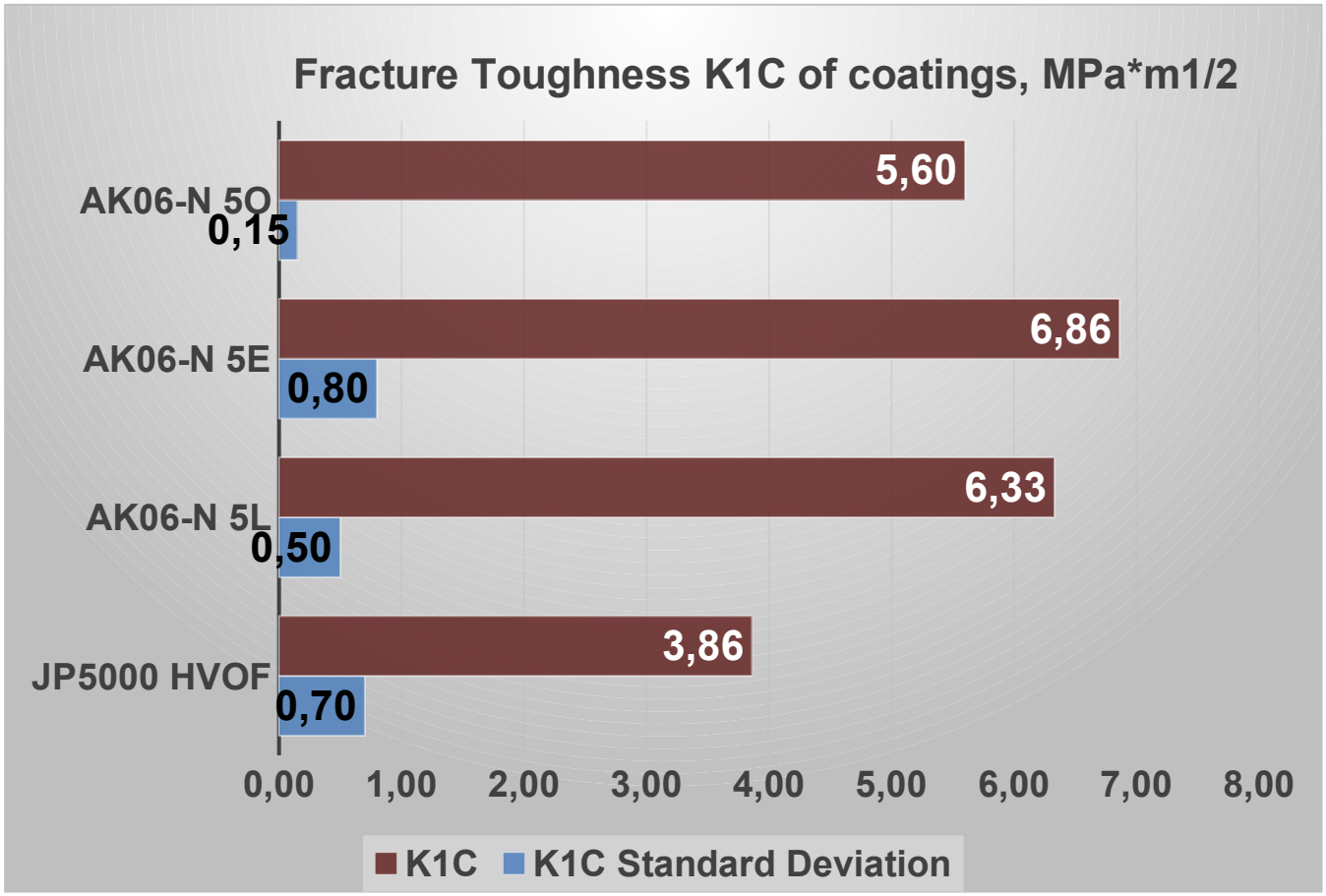
Spray Parameters: Normalized

	JP5000 HVOF	Kermetico AK6 HVAF		
		Nozzle 5L	Nozzle 5E	Nozzle 5O
Oxidizer flow, SLPM	O2: 873.1	Air: 2,104 (O2: 421.0)		
Fuel, g/sec	5.01	2.65		
O_2/Fuel Ratio vs. Stoichiometric	1.16 (Oxidizing)	1.03 (~Neutral)		
Carrier Nitrogen, SLPM	10.85	21		
Combustion pressure, Bar	7.56	5.25		
Powder feed rate, g/sec	1.50	2.22		
Particle average size, micron	27	18		
Particle velocity, m/s	740	895 +/-2	960 +/-3	1010+/-4
Particle temperature, °C	1790-1840	1470 +/-10	1460 +/-10	1470 +/-10
Particle kinetic energy, μJ	29.4	12.7	14.7	16.2
Energy density, GJ/m^3 = = Contact pressure, GPa	**3.8**	**5.6**	**6.4**	**7.1**

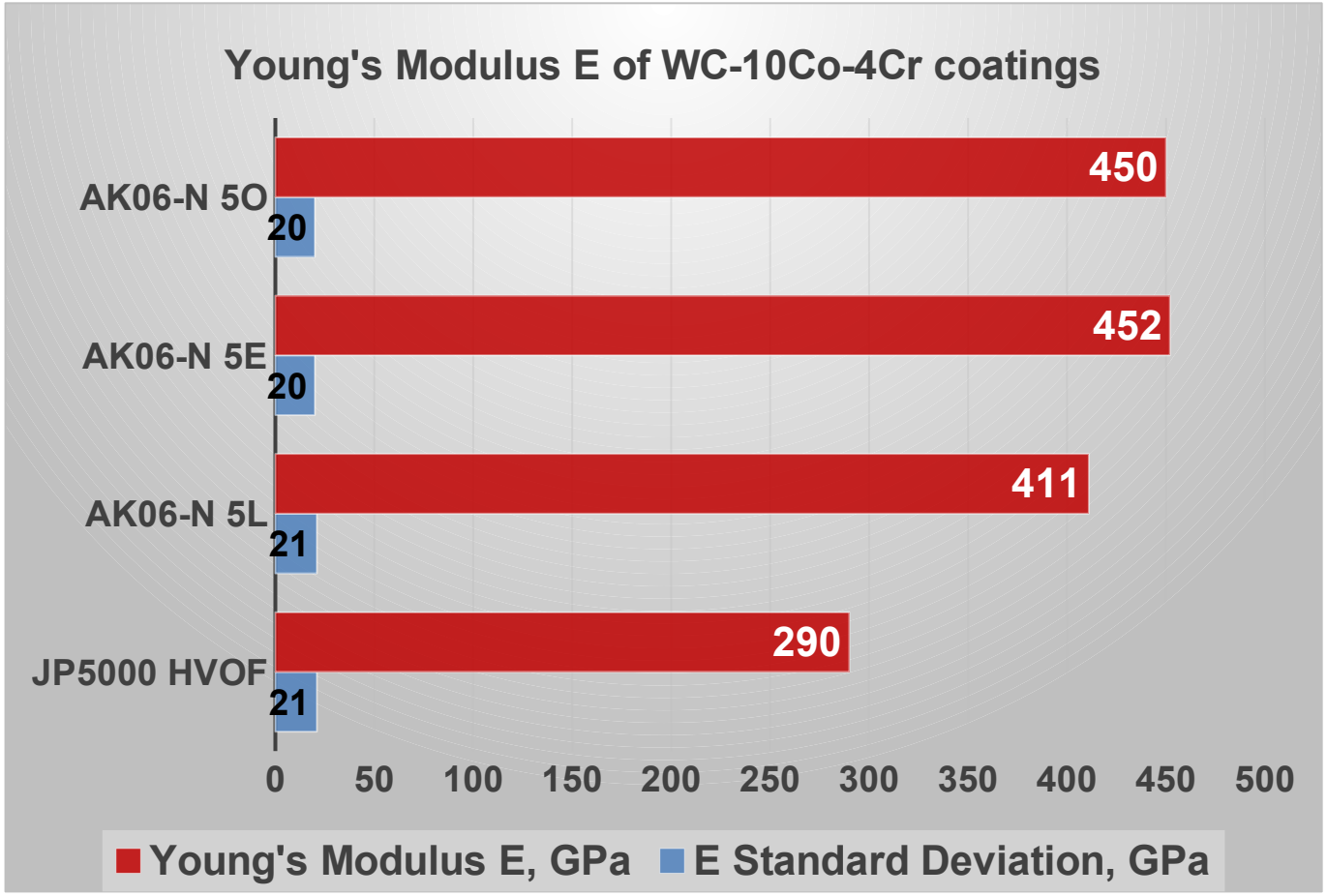
Mechanical Properties: WC-10Co-4Cr



Mechanical Properties: WC-10Co-4Cr



Mechanical Properties: WC-10Co-4Cr



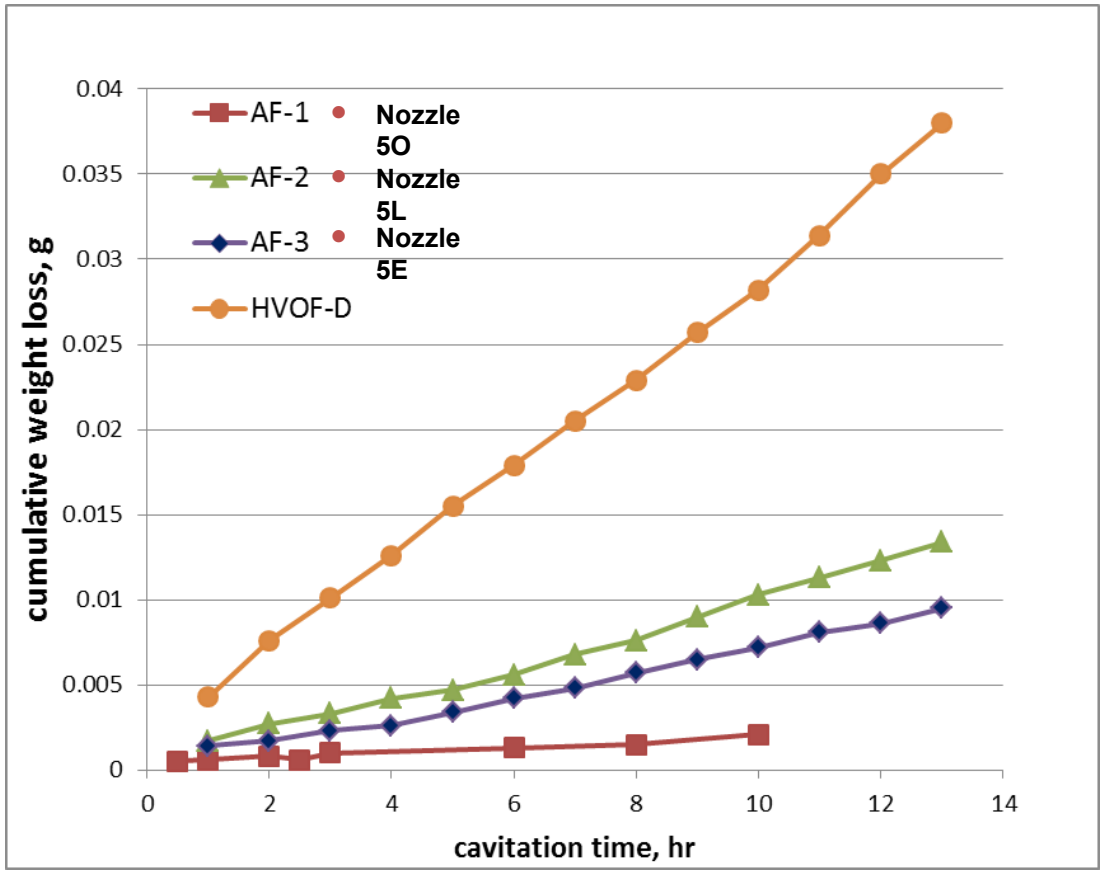
Cavitation Resistance
of WC-10Co-4Cr HVOF and HVAF coatings

(dw/dt) AF1 (5O) = 0.23 mg/h
(dw/dt) AF3 (5E) = 0.71 mg/h
(dw/dt) AF2 (5L) = 0.96 mg/h

(dw/dt) HVOF = > 3.26 mg/h

(dw/dt) 16Cr-5Ni steel = 2.0 - 2.5 mg/h

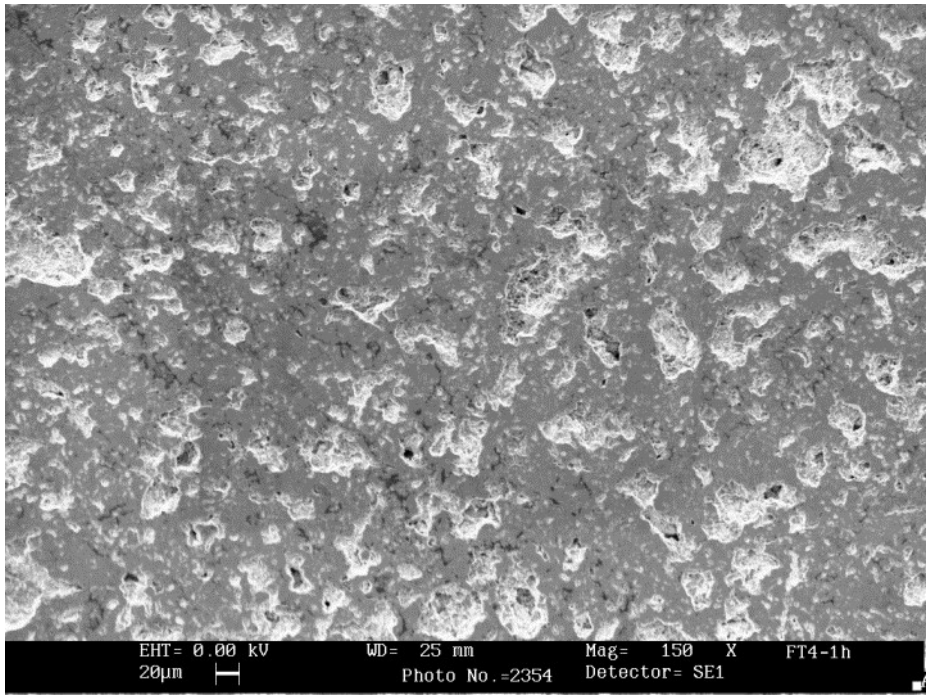
$$\frac{d\,(weight\ loss)}{d\,(time)} = dw/dt$$



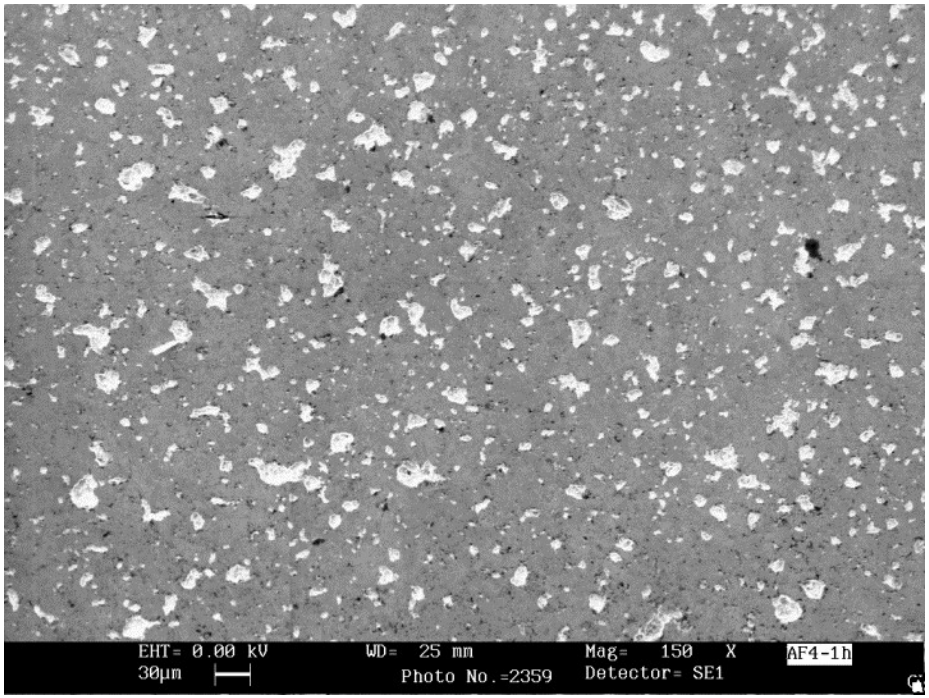
Surface SEM Micrographs of WC-10Co-4Cr Coatings after Cavitation Testing

Test duration: 1 hour

JP5000 HVOF



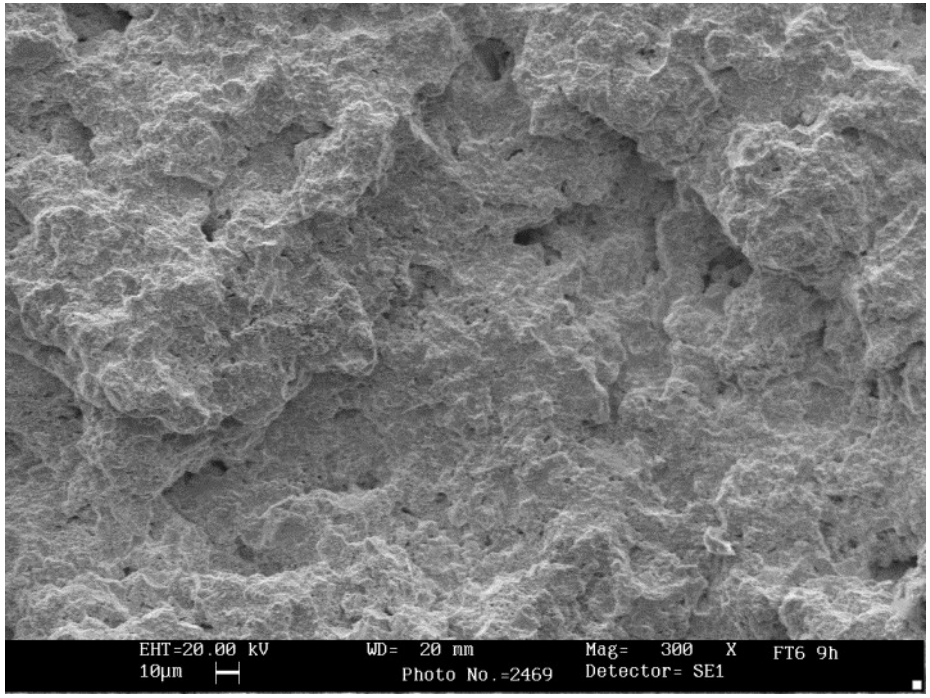
AK6 HVAF



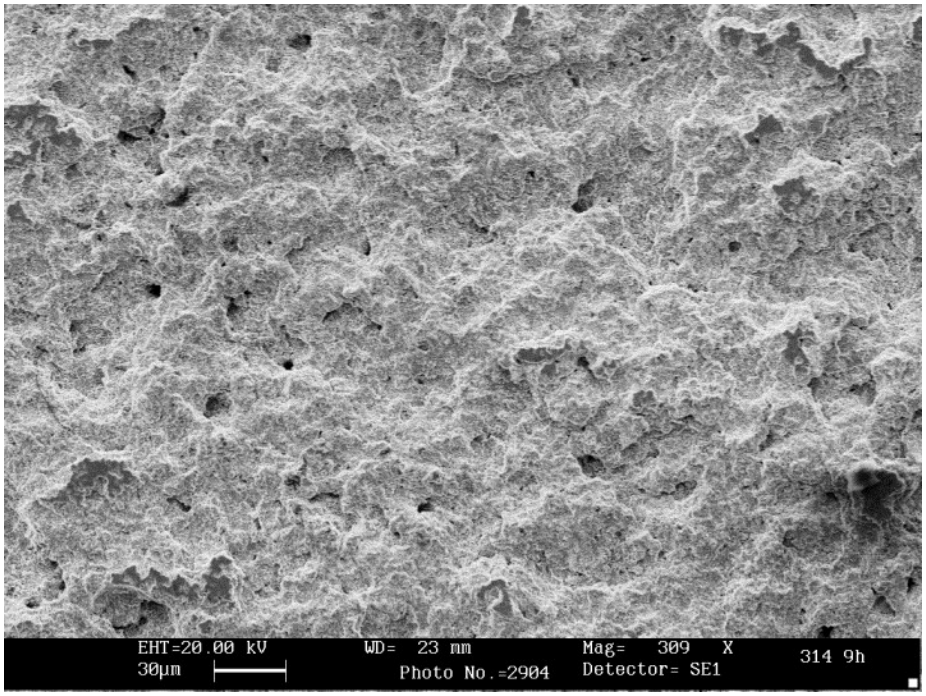
Surface SEM Micrographs of WC-10Co-4Cr Coatings after Cavitation Testing

Test duration: 9 hours

JP5000 HVOF

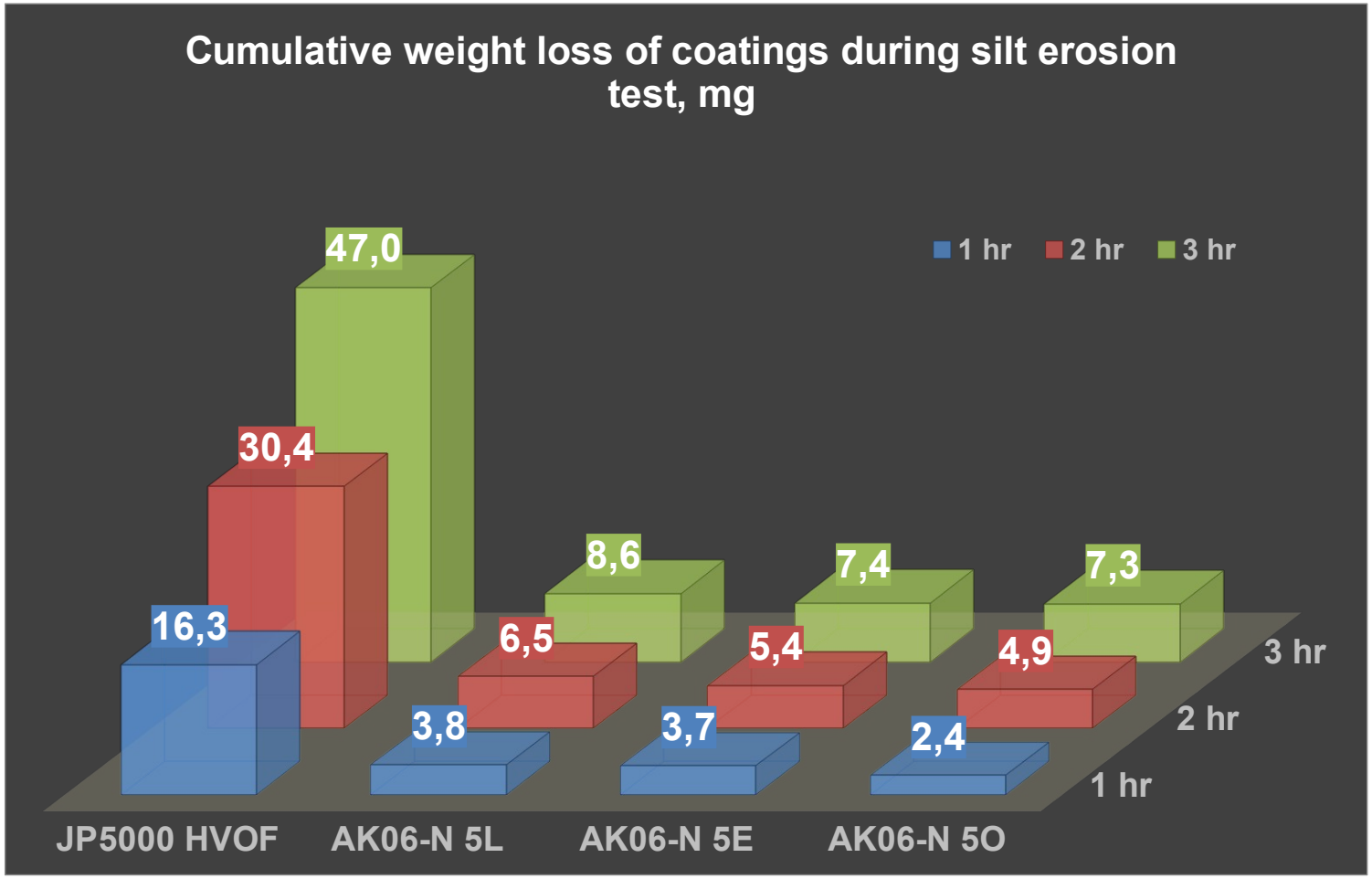


AK6 HVAF



Resistance to Silt Erosion

WC-10Co-4Cr HVOF and HVAF coatings



Other third-party data, comparing Kermetico HVAF WC-10Co-4Cr coatings to the best HVOF and Detonation systems

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Schlumberger

Test Results

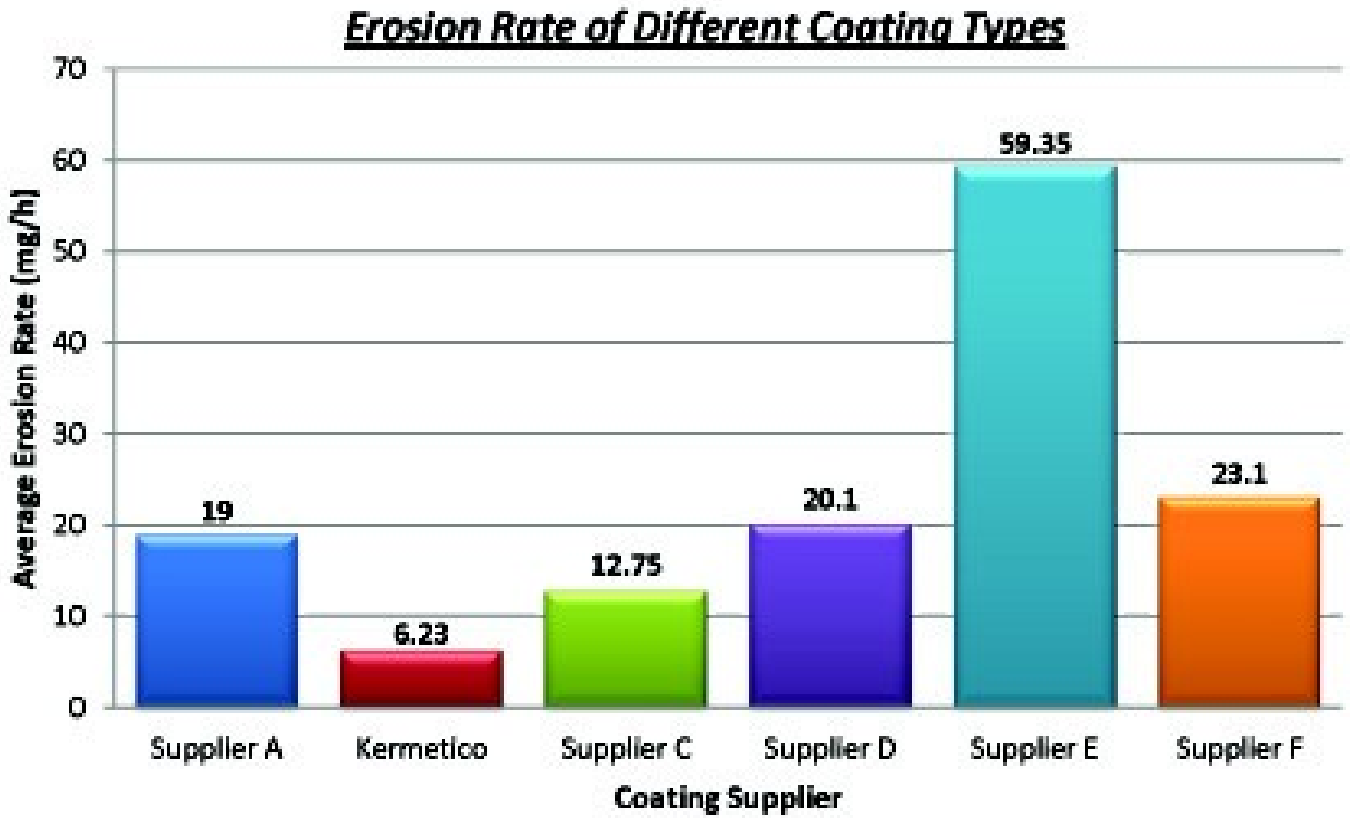
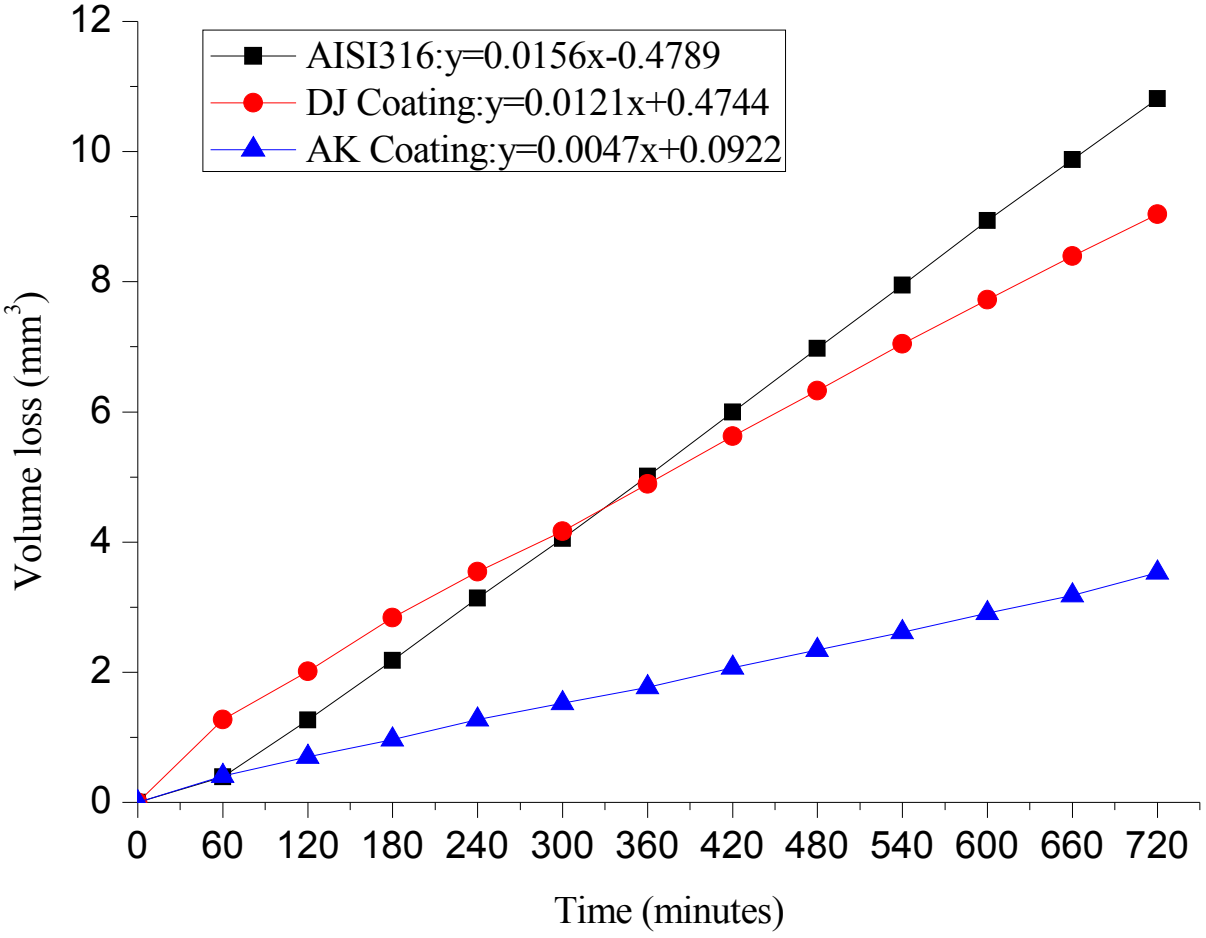


FIGURE 5 - EROSION RATE OF DIFFERENT SUPPLIER COATINGS

Hunan University
Changsha, Hunan, China:
WC-10Co-4Cr HVOF & HVAF coatings. Cavitation test

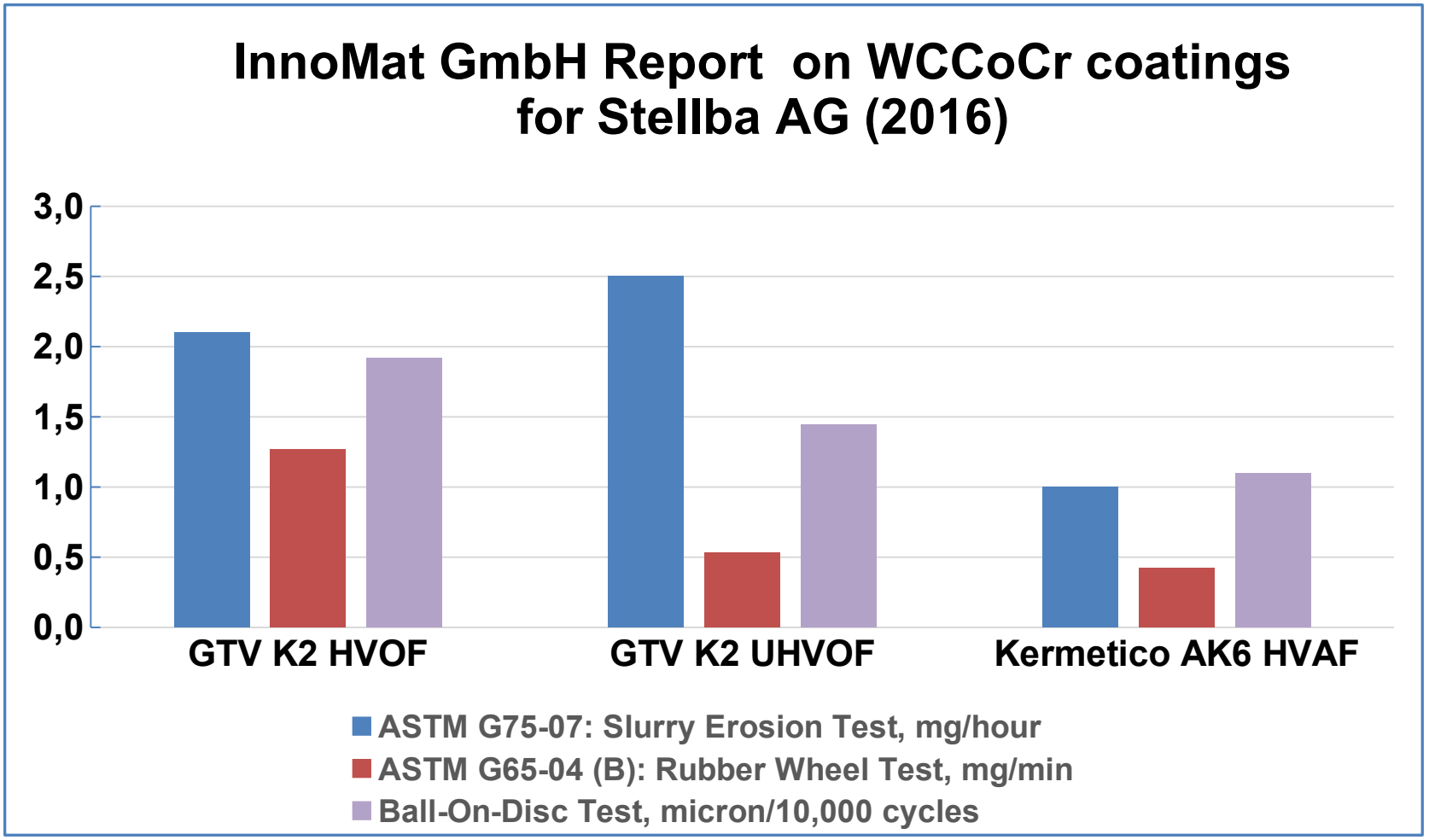


InnoMat GmbH

KERMETICO

Gesellschaft für innovative Materialtechnik
InnoMat GmbH
Annaberger Str. 240, 09125 Chemnitz

Stellba AG
Wohlerstrasse 51
CH - 5605 Dottikon



Slat Spray: All WCCoCr samples passed 312-hour test

	K2 HVOF	K2 UHVOF	AK6 HVAF
Before testing			
After 312-hours testing			

Note: HVAF samples were tested after Pin-On-Disc Wear Test

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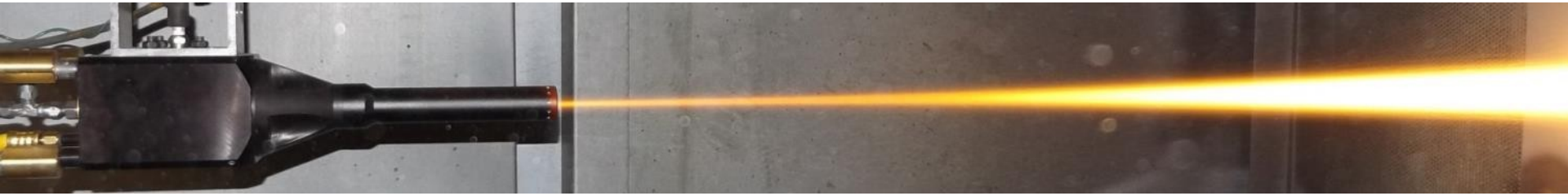
Economical aspects of Kermetico HVAF spraying: Your Choice of Cost and Quality



HVAF-E (Economy) – meets HVOF specs

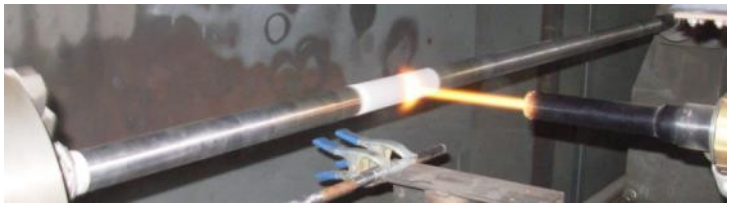
HVAF-B (Balanced) – exceeds HVOF specs

HVAF-U (Ultra) – substantially exceeds HVOF specs

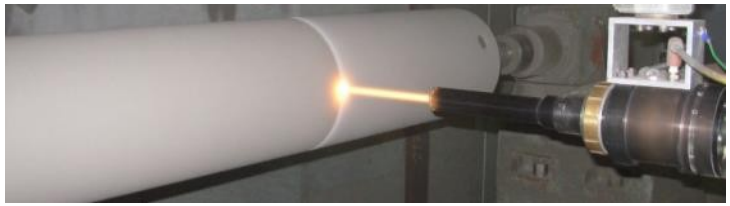
Economic aspects of Kermetico HVAF

Gun Setup	Coating Hardness , HV_{300}	Coating Porosity, %	Deposit Efficiency, %
Economy (E)	1050-1250	<0.8	65+
Balanced (B)	1250-1350	<0.5	48 - 58
Ultra (U)	1450-1700	<0.1	36 - 42

High spray rates are applicable for large and small parts



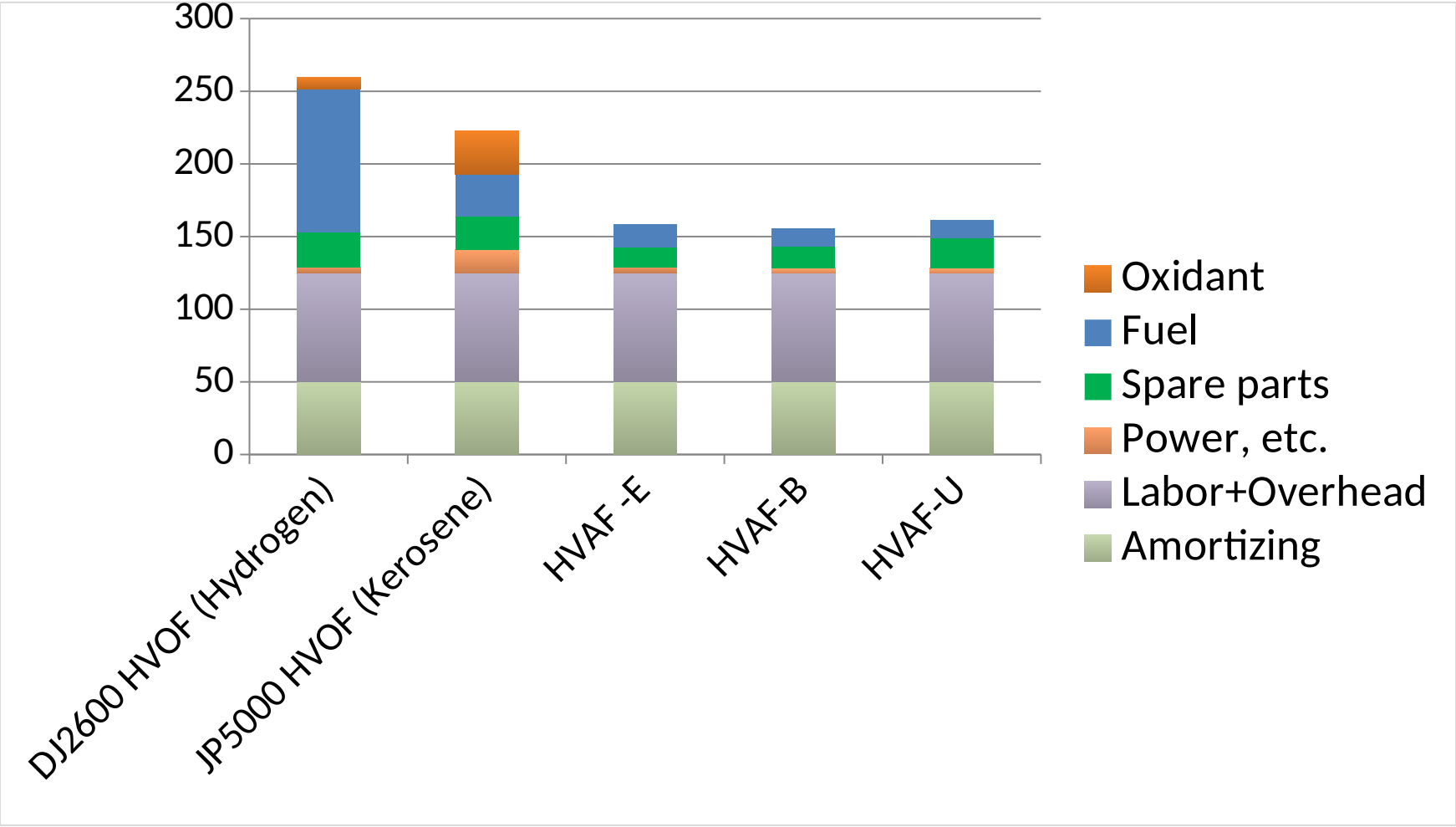
O.D. 38 mm: Rate 25 kg/hour



O.D. 330 mm: Rate 32 kg/hour

Data for WC-10Co-4Cr, agglomerated & sintered powder

HVOF vs HVAF WC-10Co-4Cr costs



Comparison of HVAF and HVOF operating costs, USD per hour (prices in Texas, USA)

Comparison of HVAF and HVOF cost
(prices in Texas, USA)

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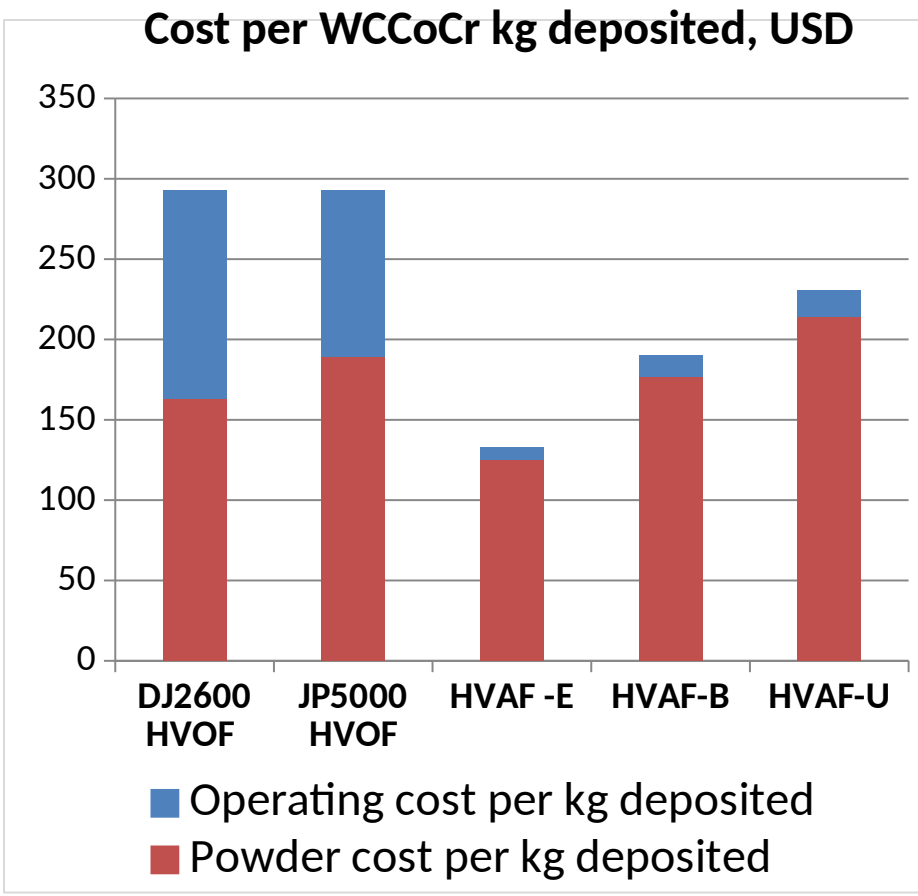
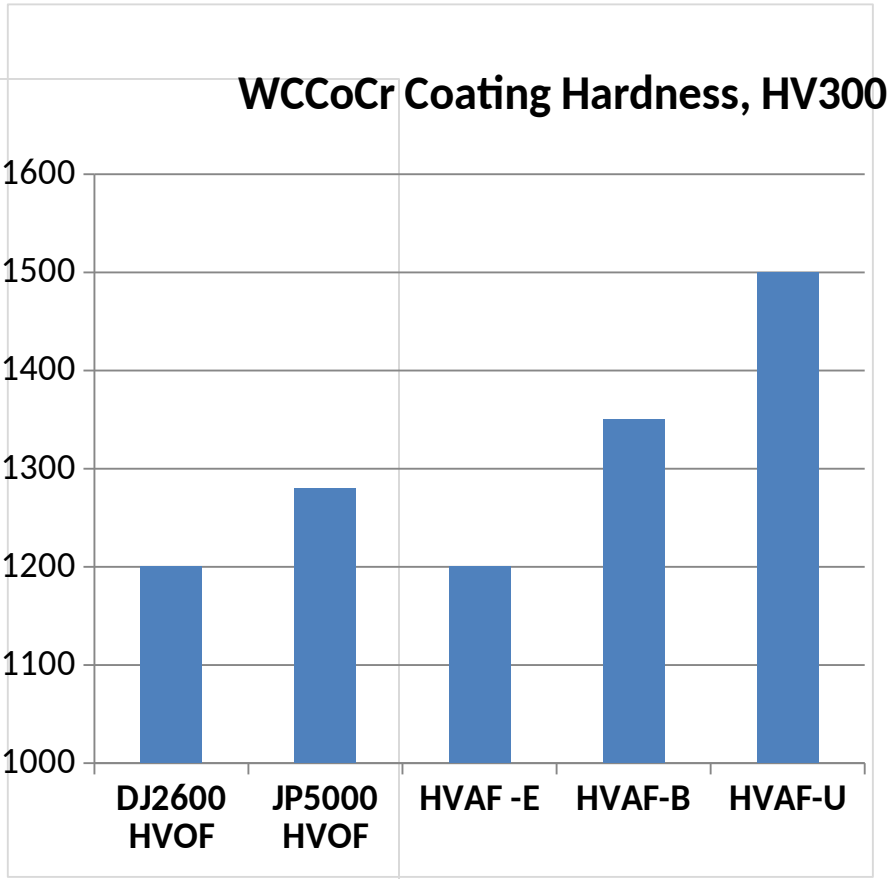




Note: Cost of WC-Co-Cr powder: $81.4 per kg

	DJ2600 HVOF	JP5000 HVOF	HVAF-E	HVAF-B	HVAF-U
Spray Rate, kg/hour	4	5	32	26	26
Deposition Efficiency	50%	43%	65%	46%	38%

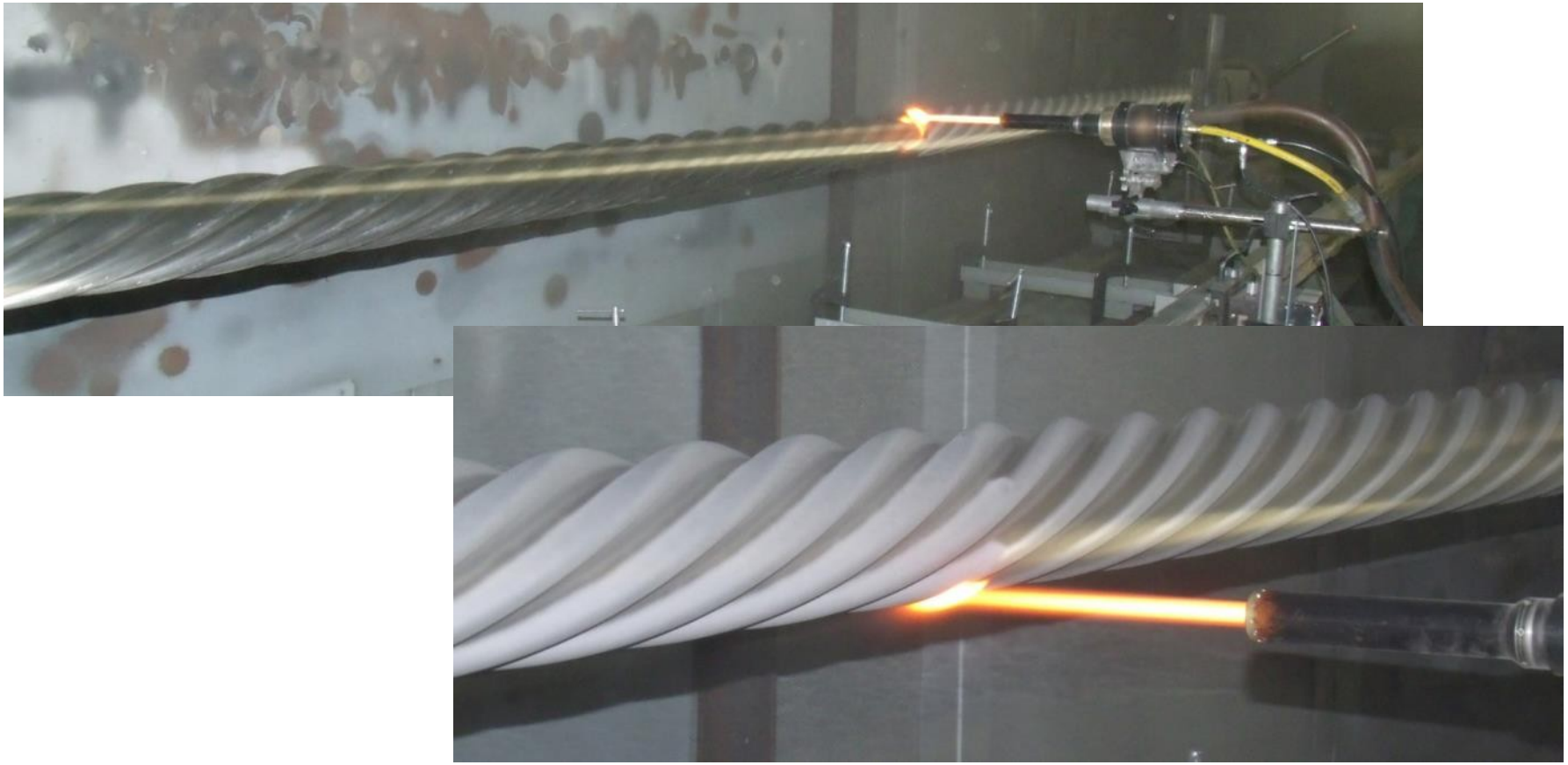
HVOF vs HVAF WC-10Co-4Cr costs

WC-Co-Cr powder cost: 81.4 USD/kg	DJ2600 HVOF	JP5000 HVOF	AK7 HVAF (E)
Total operating cost, USD/hour	260	223	160
Spray rate, kg/hour	4	5	32
Deposition efficiency, %	50	43	65
Deposition rate, kg/hour	2.2	2.2	20.8
Cost per KG of sprayed coating, USD	293	293	133
AK7 savings per KG of deposited coating, USD	160	160	

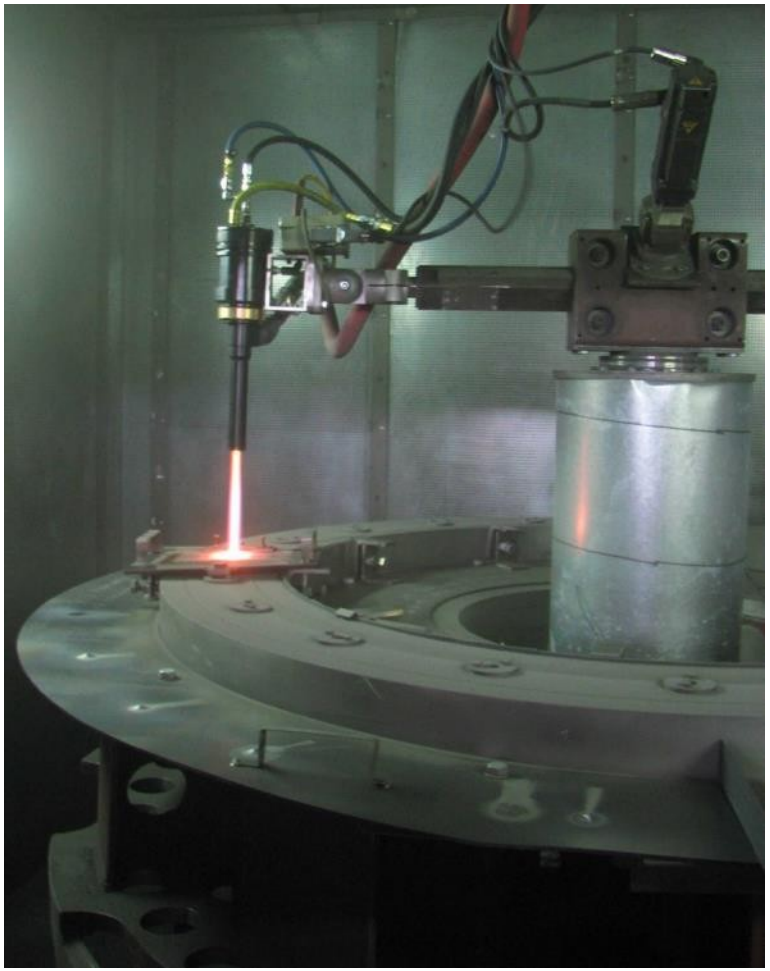
Changing a HVOF system to Kermetico HVAF saves 160 000 USD per each metric ton of deposited tungsten carbide coating

Examples of Kermetico HVAF Applications

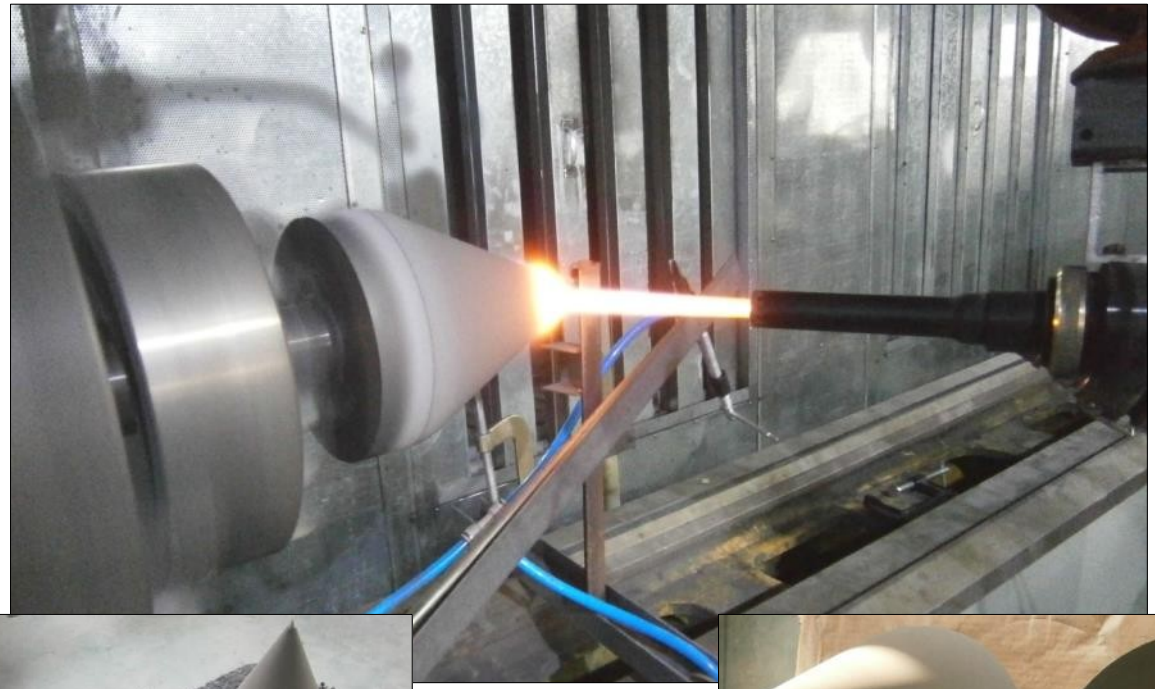
Mud rotors, oil drilling: WC-20Cr7Ni, WC-10Co-4Cr



Hydro-Power:
Francis Turbine Runner and Head Cover
WCCoCr Application by Plackart Ltd., Russia



Hydro-Power:
Metering Needle Valve and Seat
Application by RenCoat Ltd., China



Sliding Gate of Catalyst Tower

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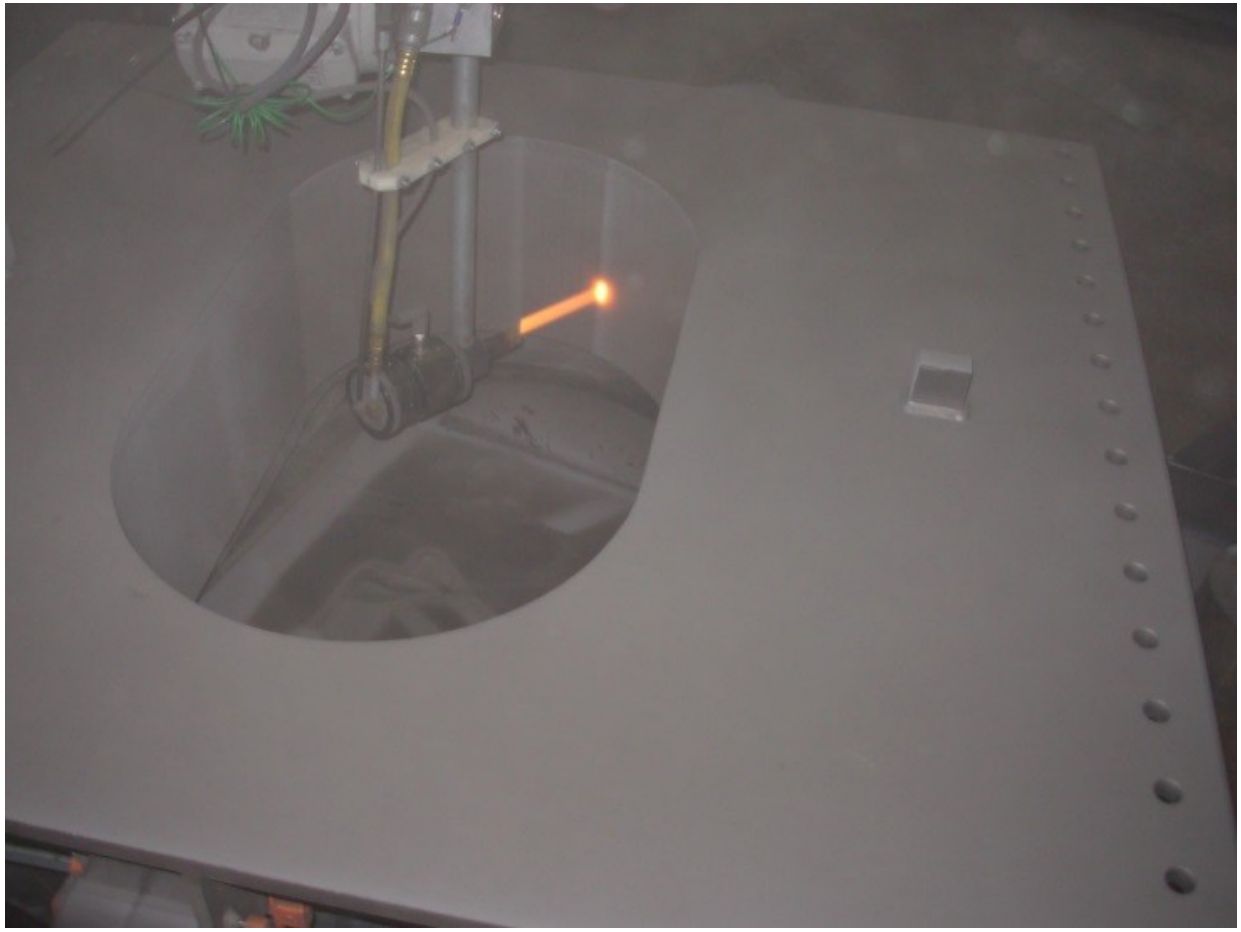
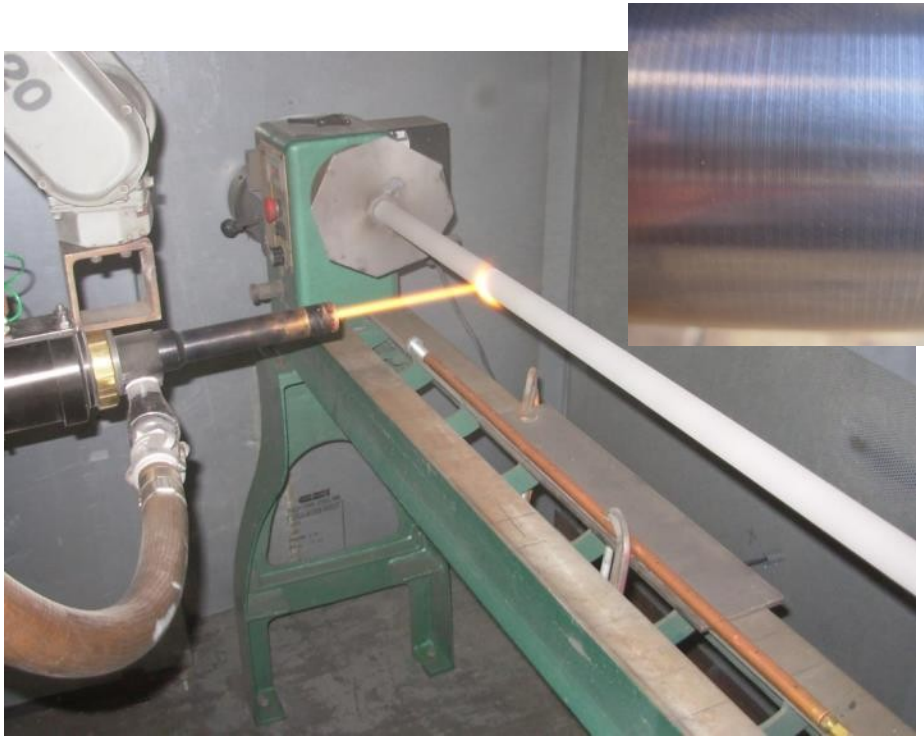
Spraying: Upper slide gate

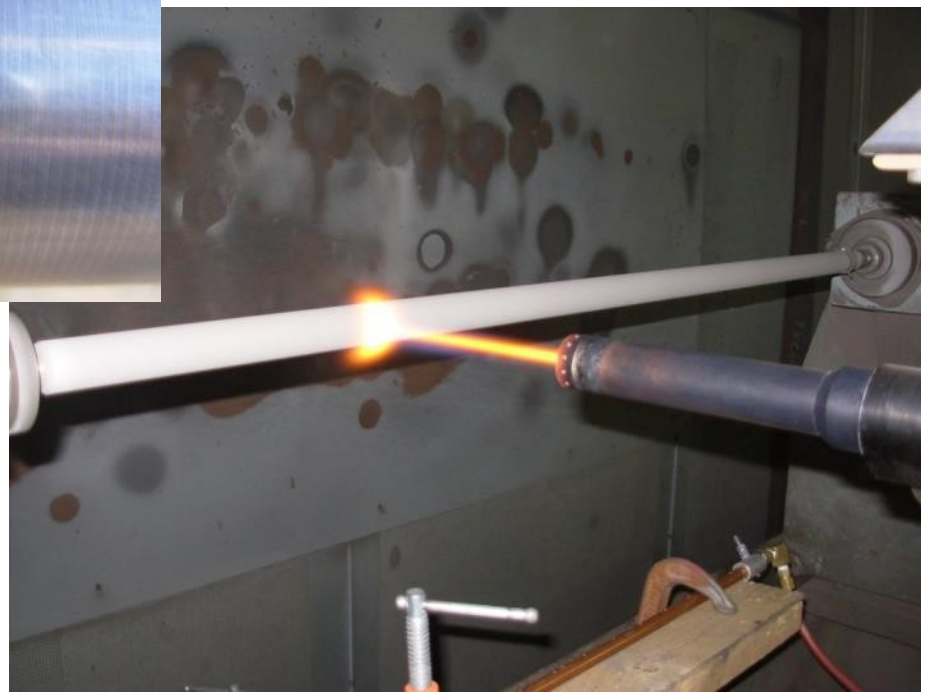


Hydraulic rods of dock cranes

Hard chrome performance: 0.5 year max (pitting)

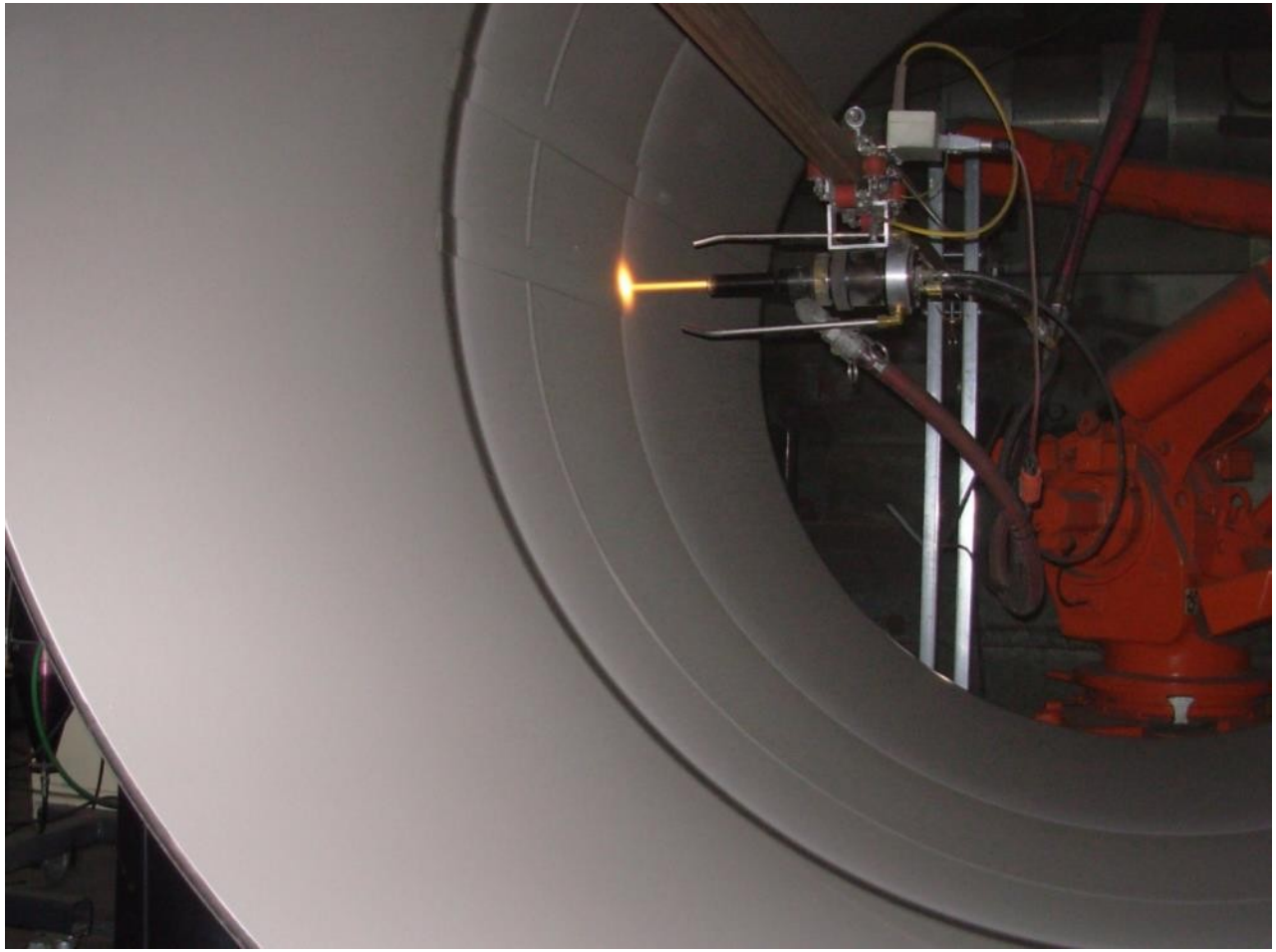
HVAF WC-Co-Cr coating performance: 4+ years





Refinery: Sulfur condenser vessel

Application of Hastelloy C HVAF coating
DIA 1.8 m x L 2.4 m



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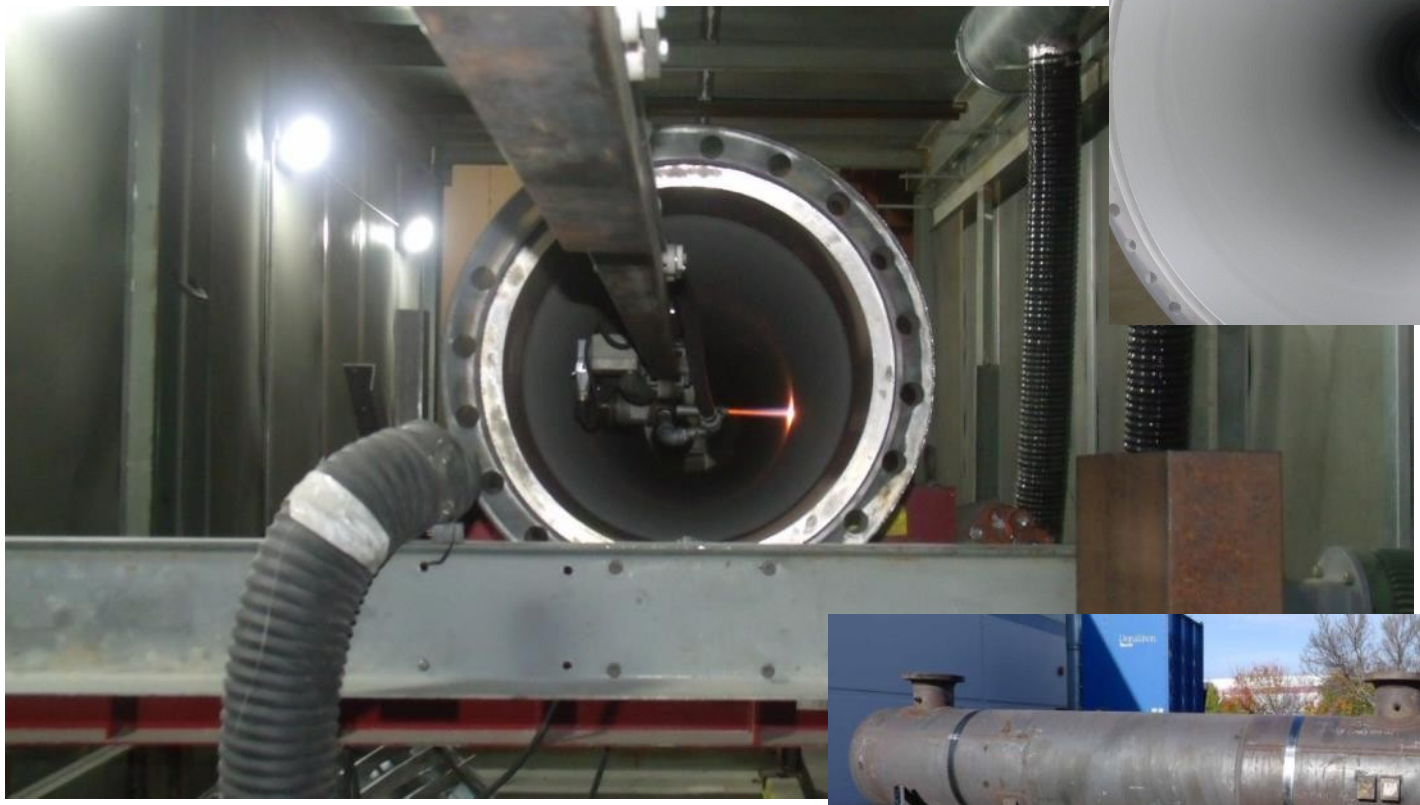
Refinery: Automated coating application with rotating AK5 gun inside closed-end process vessel

Diameter: 1.8 m

Length: 11.8 m

Refinery: Heat exchanger vessels



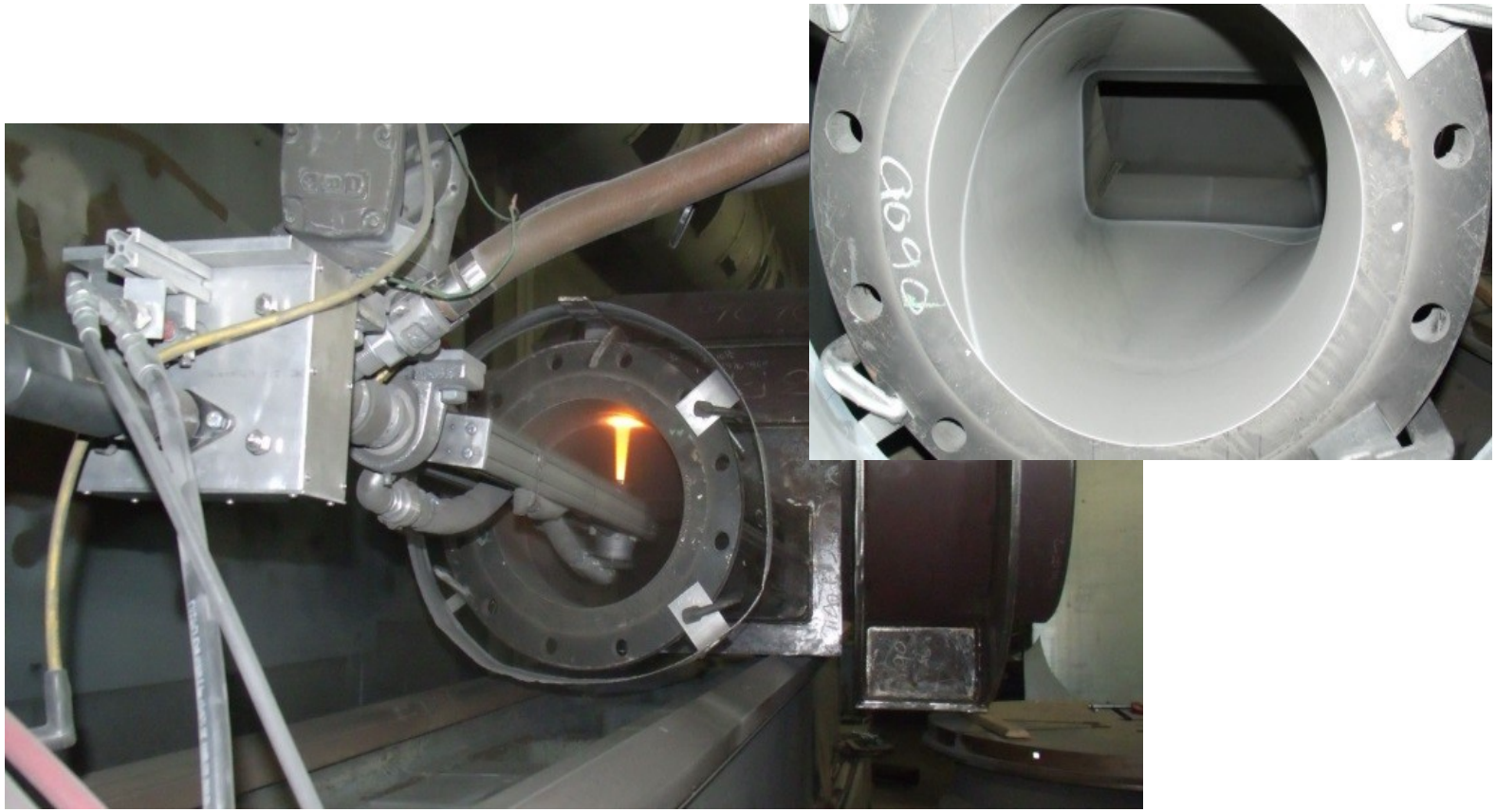
Double-Elbow, Coke transport line

12-inch ID,
6-feet long

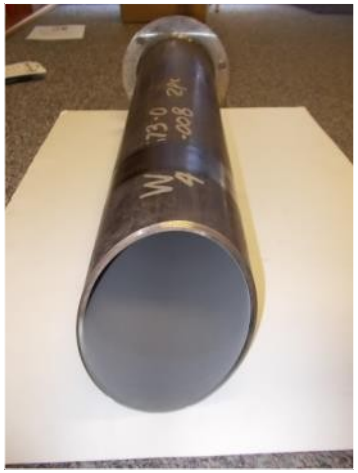
Double-Elbow, Spraying with rotating AK5 gun

Coke line cyclone:
Application of WC-10Co-4Cr coating by rotating AK5 gun

Coke line cyclone:
Application of WC-10Co-4Cr coating
by rotating AK5 gun

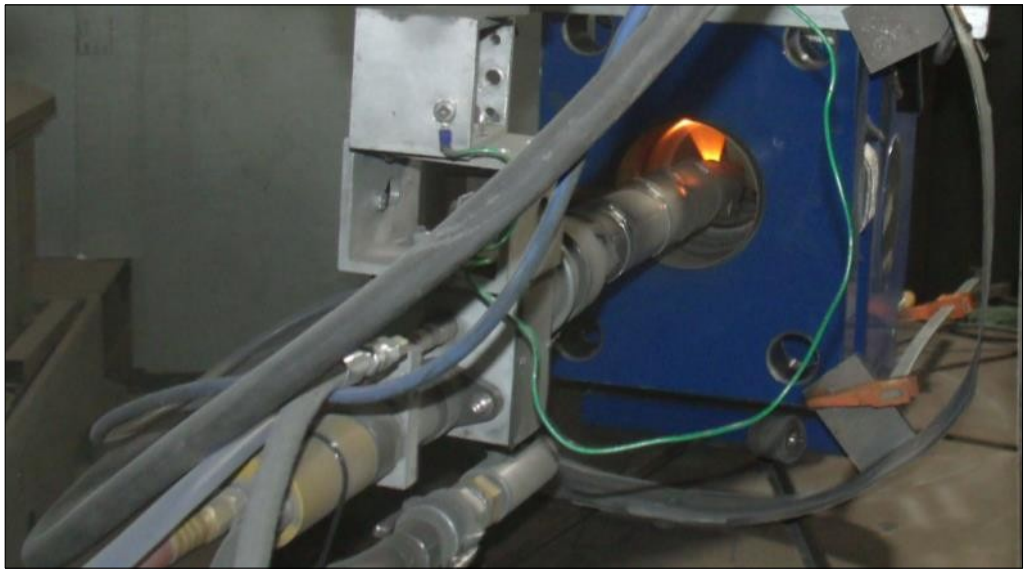


Small ID transport pipe line components: Application of WC-10Co-4Cr coating by rotating AK-IDR gun



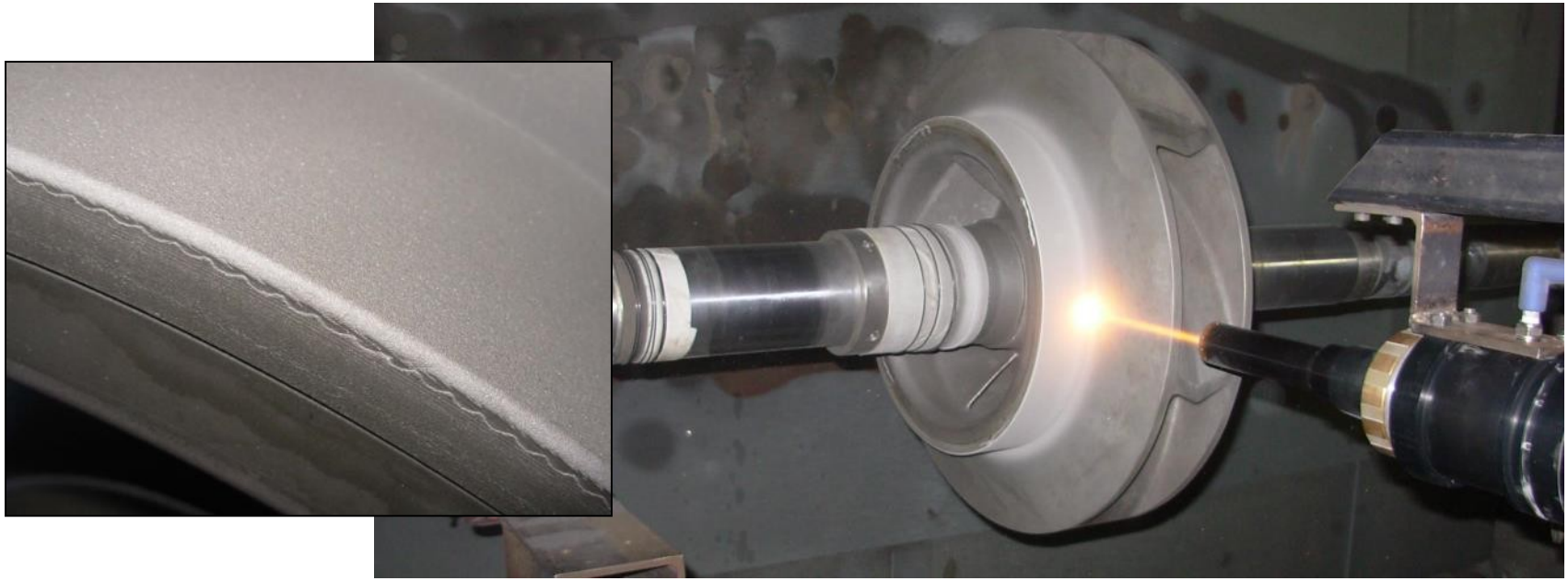
Oil Refinery:
Pump Casing ID spraying

Oil Drilling:
Fluid-End Pump Casing, 5-inch (125 mm) ID
Application of coating with AK-IDR rotating gun



Wear rings on HT pump housings and impeller hubs

AK7 Stellite 6 coating over Stellite weld overlay



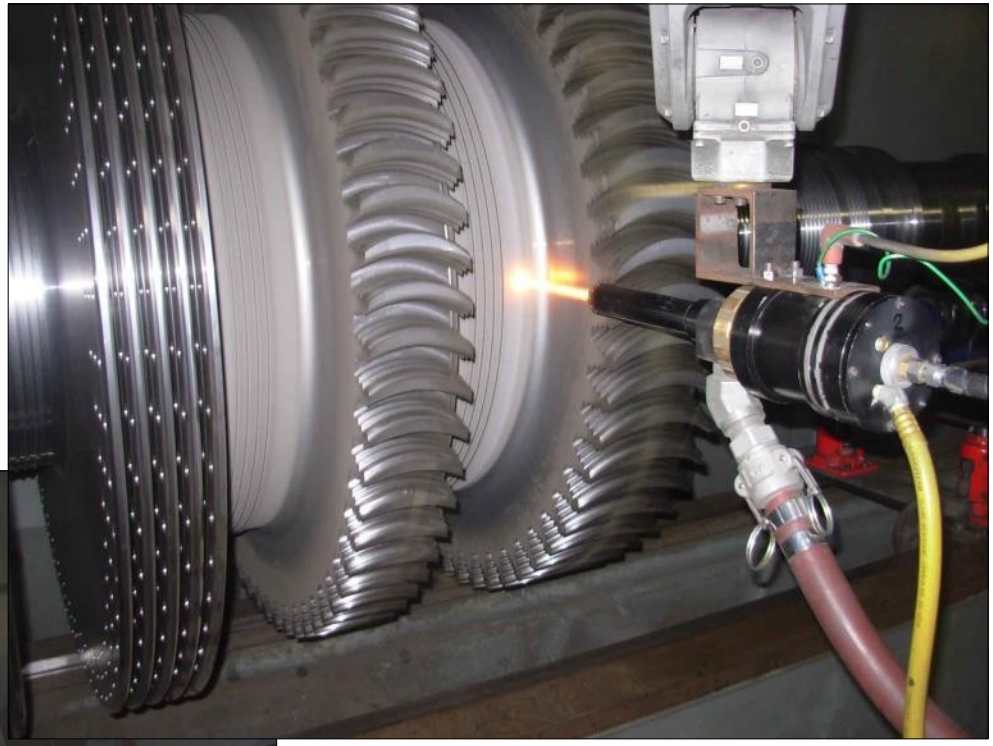
HT (400°C) Pump coating solutions:

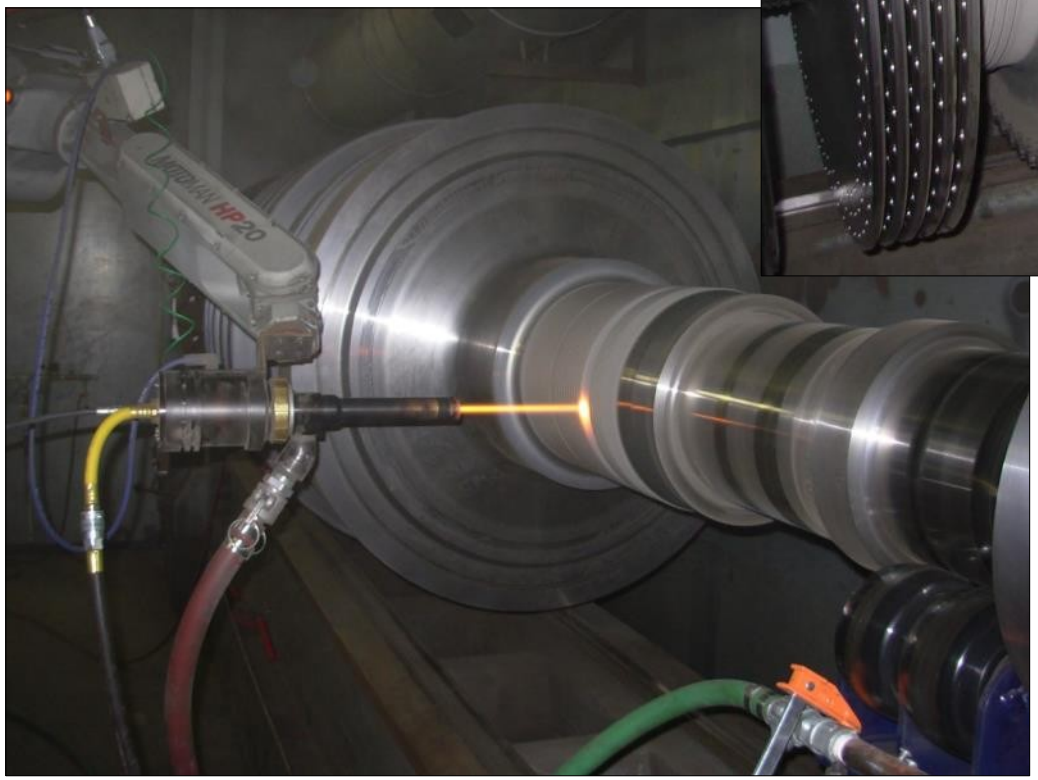
Housing ring: Stellite 6
Impeller ring: Stellite 1

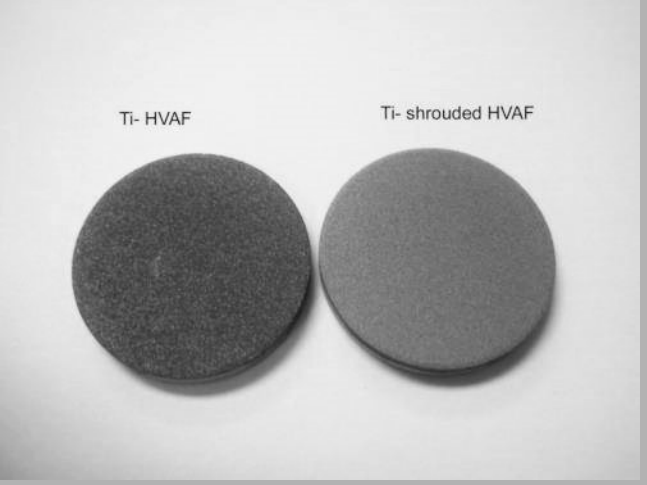
⇨

Housing ring: Stellite 6
Impeller ring: WCCoCr

Geothermal Power: Turbine Rotor WCCoCr 86/10/4



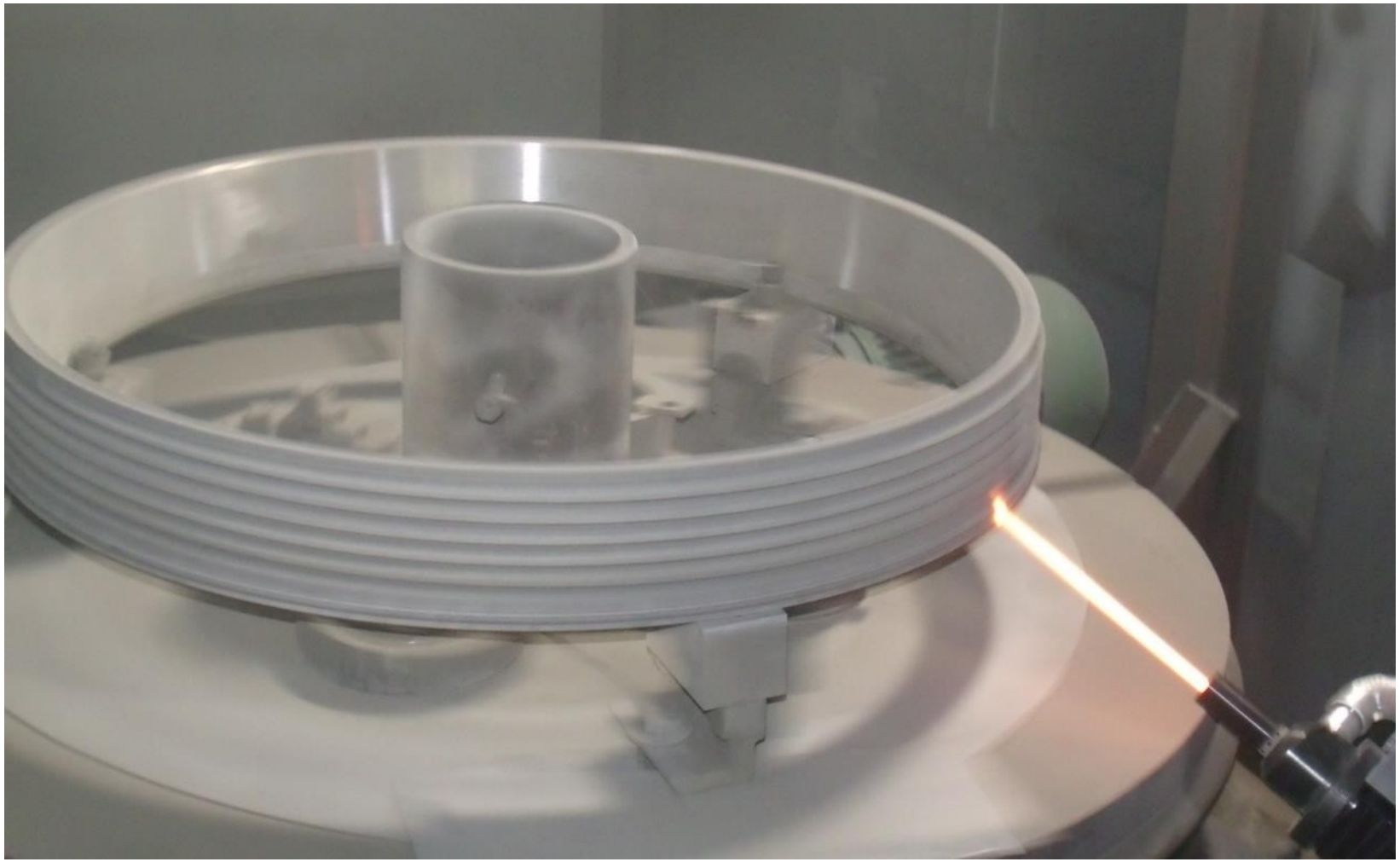




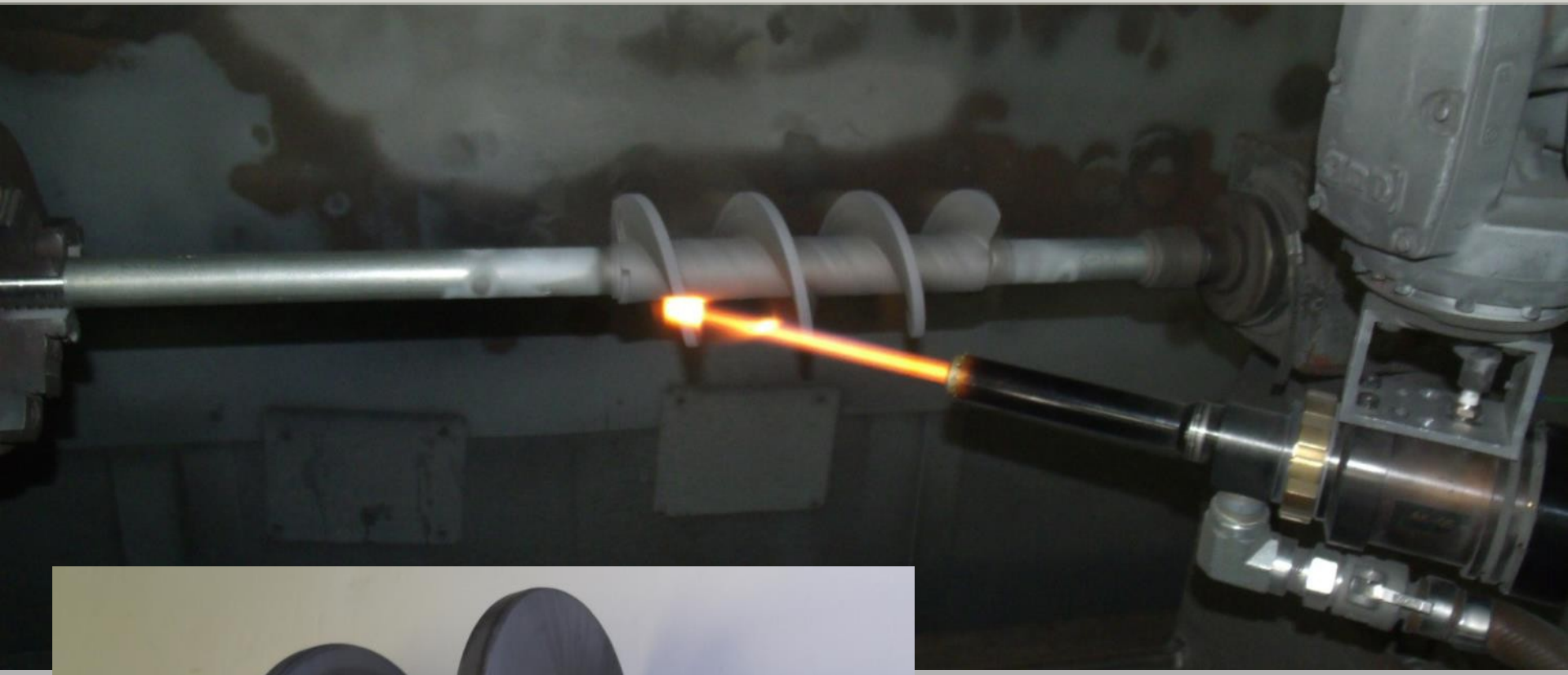
Titanium: HVAF

Titanium: Shrouded HVAF

Tin Spraying with SL HVAF gun for low-melting point metals



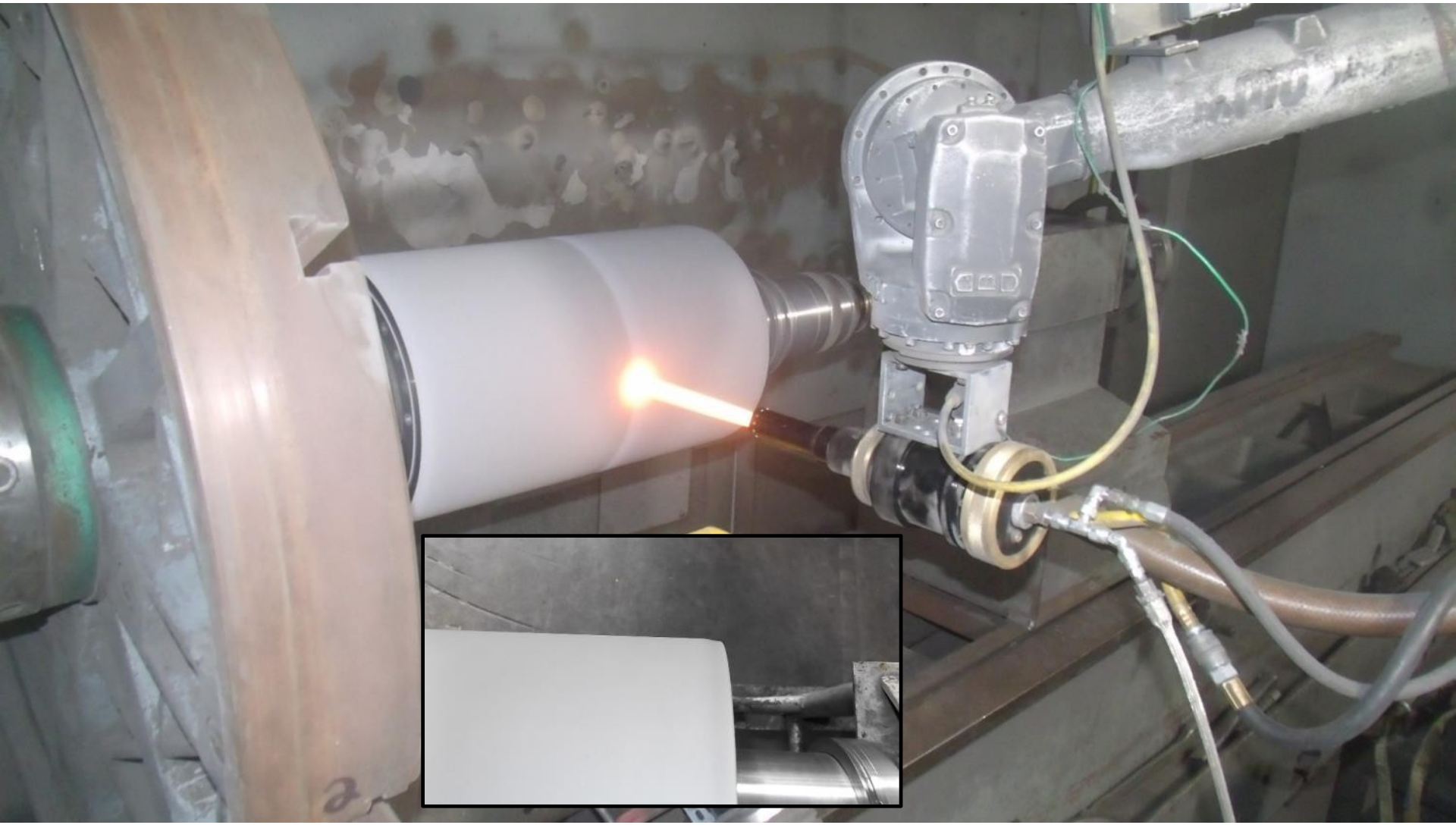
Kermetico HVAF



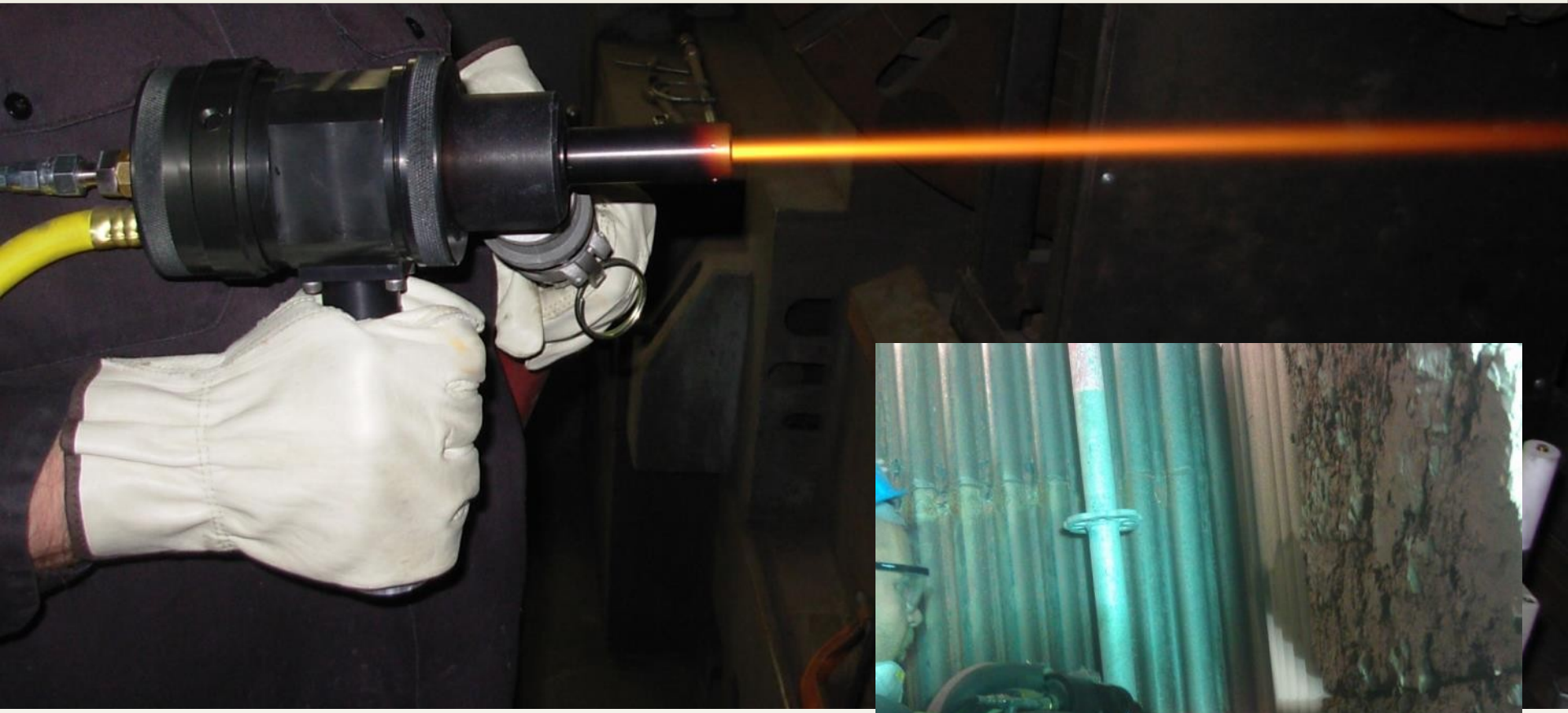
WC-Co-Cr

1 mm thick

Tensiometer Roll:
AK7 HVAF, WC-10Co-4Cr, 1.8 mm thick



Kermetico HVAF Blast & Spray Systems



AK-HH: hand-held HVAF

Press pistons, Winemaking