CADORATH

Extreme Wear Solutions

Oil & Gas, Mining, Aerospace, Agriculture & Industry

Definition: Extreme Wear Solutions

The manufacturing and repair methods used to produce custom, application-specific, superior performing parts.

Benefits of using Extreme Wear parts:

- **Reduction of costly downtime** with the use of superior performing Extreme Wear parts
- **Reduced part replacement** or repair costs
- **Reduction of maintenance** & operating costs due to longer service cycles with Extreme Wear parts

Hard Chrome Plating vs. HVOF

Why the Technology?

- Used for fluid power hydraulic repairs in cylinders and corner groups
- Provides long-term robust repair for hydraulic and fluid power components
- Cutting edge environmentally friendly technology
- Provides a safe working environment for associates to do repairs

Hard Chrome Plating

Chrome was discovered in 1798, first successful electrolytic plating in 1856, with commercial utilization in the late 1920's

Advantages

- Resists most chemicals, oxygen, and moisture in air
- Does not tend to seize, gall, or cold weld
- Hard surface typical 69 Rc, 0.003-0.015" typical thickness
- Simple technology
- Excellent wear resistance
- Historically relatively inexpensive

Issues with hard chrome plating

- The process produces large amounts of hydrogen gas in the gas bubbles burst throwing hexavalent chrome solution into the air as fine mist. Hexavalent chrome is a know carcinogen.
- The process produces large volumes of toxic waste.
- EPA and OSHA have mandated more stringent stack emission levels and lowering of permissible exposure limits for workers.
- This results in increased costs and business risks.

ASK us about our EXTREME WEAR line of Packing Sleeves!

Hard Chrome Plating vs. HVOF

Cont'd

Alternatives to Hard Chrome Plating Sought

- The Hard Chrome Alternatives Team (HCAT) formed during the 1990's
- HCAT is a bi-national team comprised of Dept of Defense, US airlines, Canadian military and airline industries, support manufacturers
- Methods evaluated were Arc Spraying, Plasma Spraying, Flame Spraying, and **High Velocity Oxy-Fuel (HVOF)**

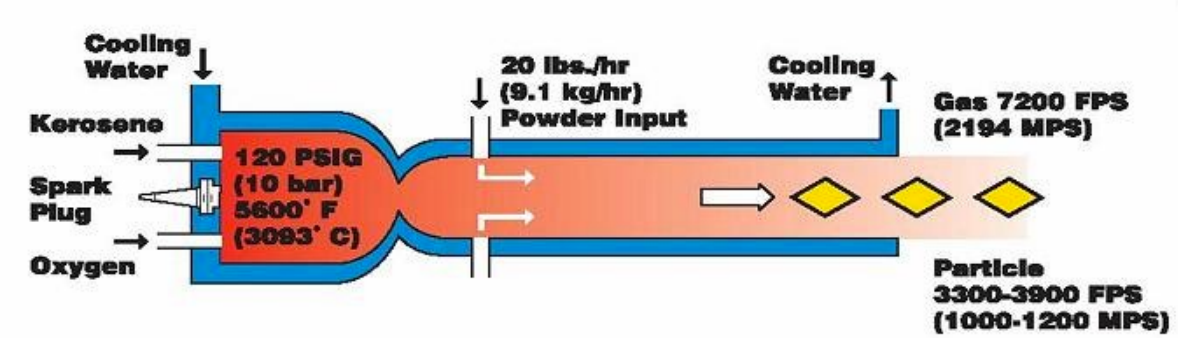
The BEST Alternative

- The best clean alternative method determined by HCAT was **HVOF** thermal spray for Hydraulic Actuators (Cylinder Rods)
- The **HVOF** process utilizes a material in powder form injected into a flame of supersonic gas
- The material softens in the flame and forms a dense coating on the substrate.

HVOF

- The fuel for the flame is a gas such as hydrogen, acetylene, propylene, or a liquid such as kerosene
- The coating material is usually a metal alloy such as chrome carbide
- Typical deposit coating layers range from 0.003-0.015" in thickness

HVOF Spray Gun Cutaway



Hard Chrome Plating vs. HVOF

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HVOF

- The two primary companies that make the HVOF spray equipment are Sulzer-Metcoand Praxair/TAFA

	Sulzer-Metco	Praxair/TAFA
Fuel	Hydrogen, propane proplyene, natural gas	Kerosene
Carrier Gas	Nitrogen	Nitrogen, Argon
Oxidizer	Oxygen	Oxygen
Particle Velocity	Mach 1	Mach 2+ (3300-3900 ft. / second)
Temperature	5000 F	5600 F

HVOF

- The part to be coated must have chrome removed by stripping electrolytically or grinding
- If the surface has been previously HVOF coated, the surface must be ground to remove any imperfections
- Any area not to be coated must be masked off
- The surface to be coated must be thoroughly grit blasted using aluminum oxide material-36 grit-the prepared surface must be kept clean from this point on
- The work piece is put into the HVOF thermal spray cabinet.
- During the spray process the work piece rotates at 300 surface feet per minute
- Each pass applies 0.001"of coating
- The work piece temperature is not allowed to exceed 350 F, the spray process can be stopped and started to limit this temperature HVOF
- Final surface finishing requires use of either diamond belts or diamond grinding wheels
- It is necessary to not only grind but also superfinish
- The finished surface is measured and documented
- The bond strength is >10,000 PSI

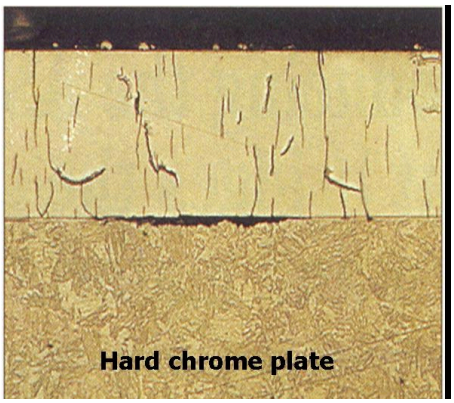
Comparison of Hard Chrome Plating to HVOF

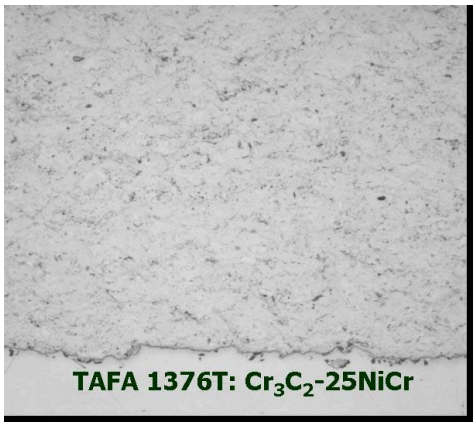
	Hard Chrome Plating	HVOF
Surface Hardness	69 Rc	71 Rc
Time required to coat Komatsu 830E first stage	7 hours (0.002" per hour to get 0.007"/side)	1 hour (12lbs at 12lbs/hr to get 0.007"/side)
Work Piece Temp	145F	300-350F
Post Plate H2 Relive	Mach 1	Mach 2+ (3300-3900 ft. / second)
Temperature	5000 F	5600 F

Hard Chrome Plating vs. HVOF

Cont'd

- At the bottom of each photo is the substrate material which is being coated





Benefits of HVOF Coatings

- High density, low porosity
- Improved corrosion barrier
- Higher hardness ratings
- Improved wear resistance
- High bond strength
- Thick coatings
- Smoother as-sprayed surfaces

Summation

- Hard chrome has the advantage that it is a single material and deposition method that can be used for a wide variety of applications
- **HVOF** is a single technology, with a wide variety of materials that can be used to achieve the right combination of properties for many purposes.

Hazardous Environment Changes

- Provides a safer work environment for our people
- 80% reduction in hazardous waste
- Waste produced is considerably less hazardous than Hard Chrome Plating