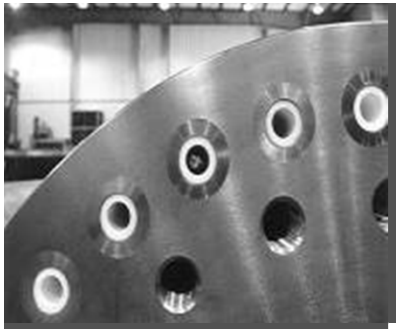
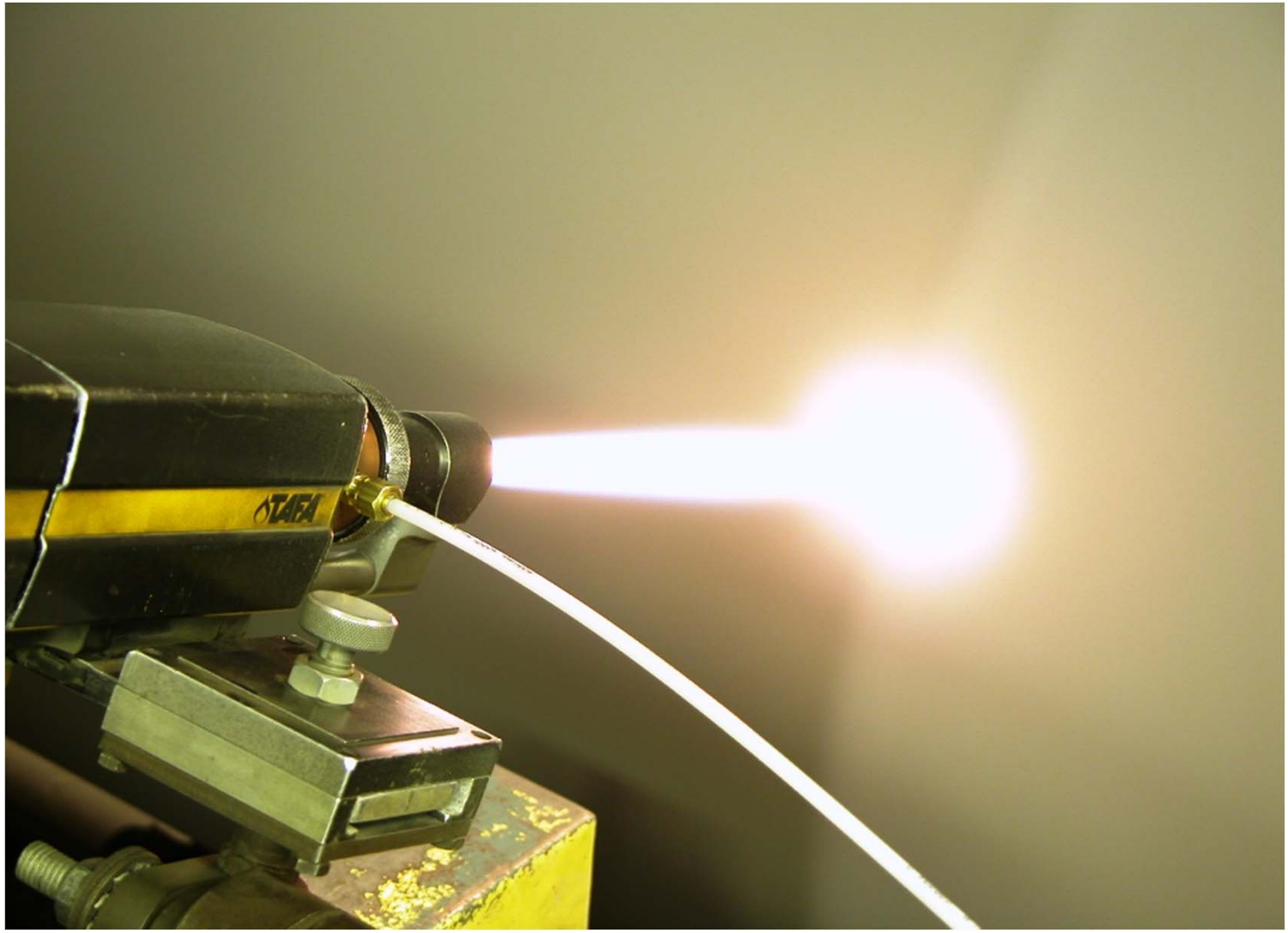
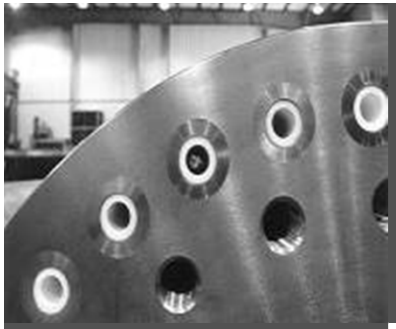


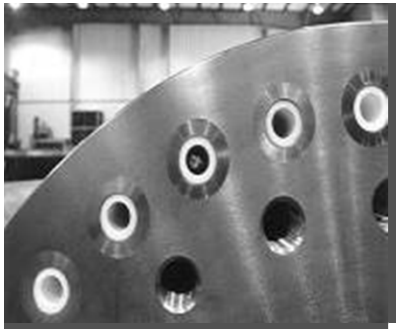
# Hard Coating





# Hard Coating Benefits

- **Increases roll surface hardness up to 1200 Vickers.**
- **Improves roll smoothness down to 1 Ra.**
- **Increases intervals between roll grinds up to 300%.**
- **Eliminates the need to grind rolls due to sheet deckle changes.**
- **Improves rolls' resistance to barring.**
- **Eliminates corrosion problems.**

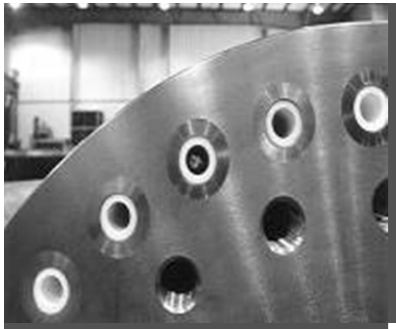


# What is WC?

**Tungsten carbide (chemical formula: WC) is a chemical compound (specifically, a carbide) containing equal parts of tungsten and carbon atoms. In its most basic form, tungsten carbide is a fine gray powder. WC is readily wetted by both molten nickel and cobalt. The material is usually called tungsten-carbide cobalt (WC-Co): it is a metal matrix composite where tungsten carbide particles are the aggregate and metallic cobalt serves as the matrix. Oxidation of WC starts at 500–600 °C (932-1112˚F).**

**Tungsten carbide is approximately two times stiffer than steel and is much denser than steel or titanium.**

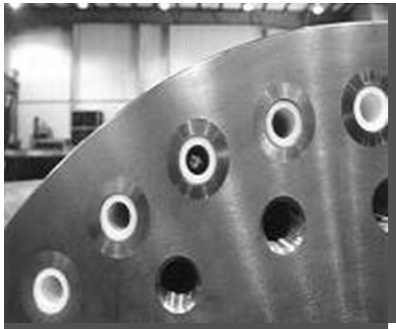
**Source:** ***CRC Handbook of Chemistry and Physics (90th ed.).*** **Boca Raton FL: CRC Press.**



# Hard Coating Materials

## Tungsten Carbide Cobalt

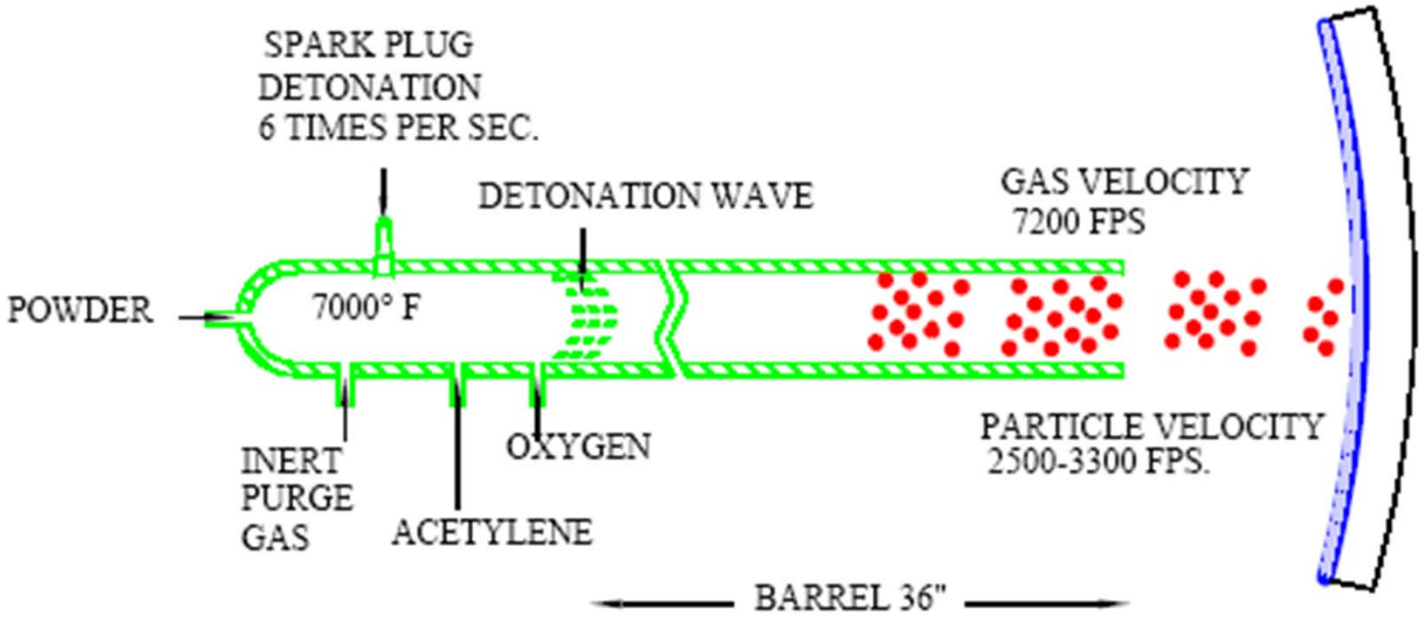
- **Hardness: 1200 Vickers**
- **Density: 98%**
- **Bond strength to roll : >13,000 PSI**
- **Surface finish: can be super-polished to 1 Ra mirror finish.**



# Earliest Hard Coating Process

## Super D-Gun: Developed by Praxair

SUPER D-GUN



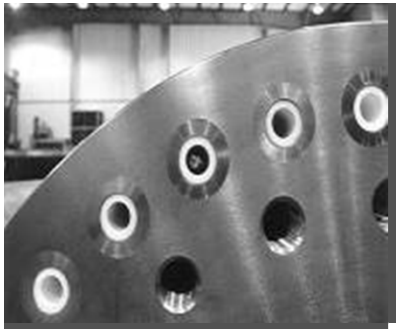

LONGER BARREL LENGTH = LONGER PARTICLE DWELL TIME = PARTICLE OXIDATION

HIGHER FLAME/PARTICLE TEMPERATURE (ACETYCENE) = MORE OXIDATION

COATING IN TENSION

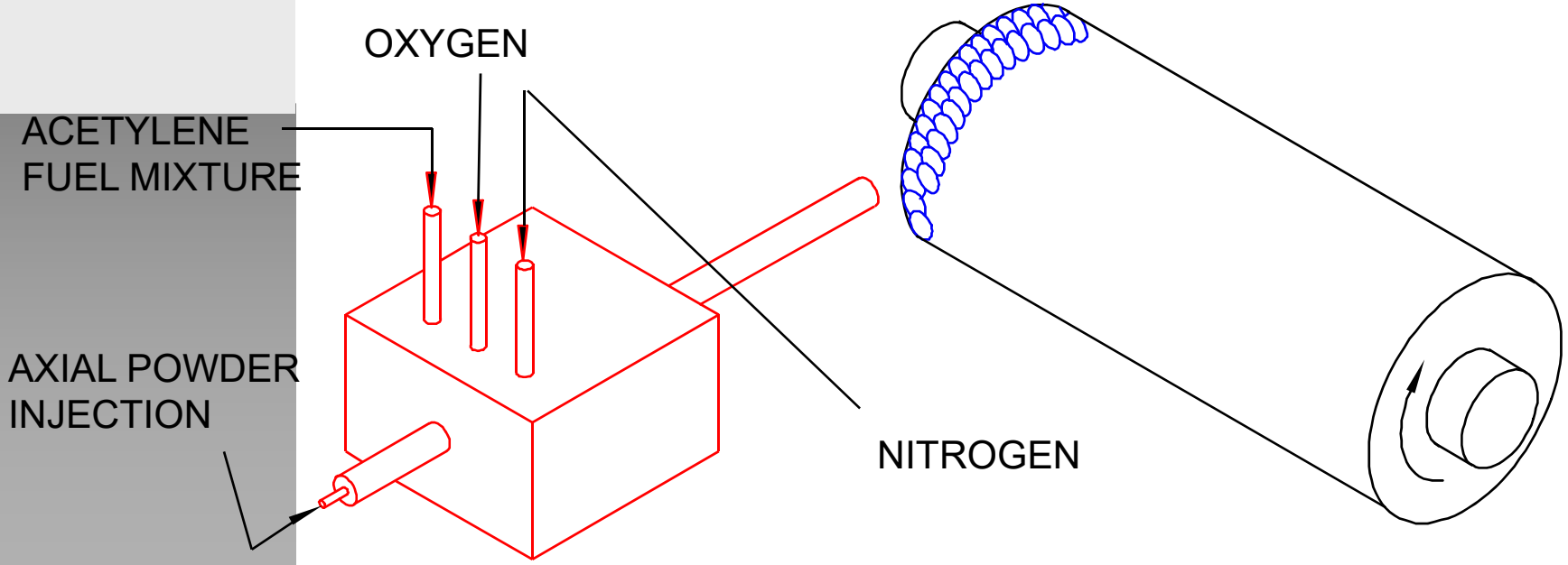
PARTICLES IN MOLTEN STATE - NO STRESS RELIEF

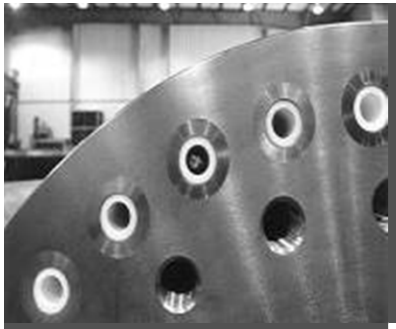
LIMITED COATING THICKNESS DUE TO INCREASED STRESSES



# D-Gun Application

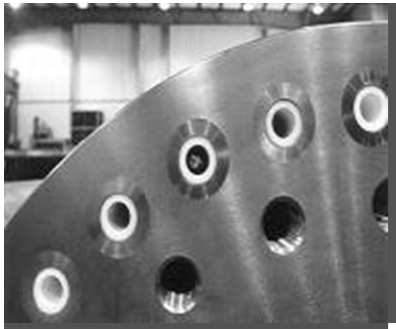
- **Individual, potentially non-uniform, burst pattern application.**
- **Strong potential for porosity in coating layer requiring application of a sealer.**





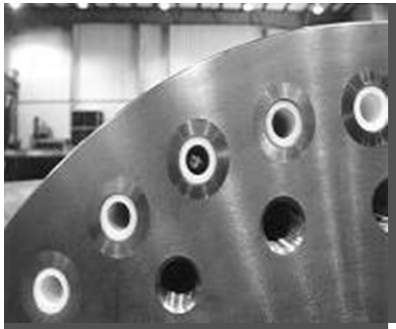
# What is “Tension”

**“Tension” is produced when atoms or molecules are pulled apart from each other and gain electromagnetic potential energy. Each end of a string or rod under tension will pull on the object it is attached to, to restore the string/rod to its relaxed length.**



# D-Gun Drawbacks

- **Particles melted & applied at in long barrel at 7000° F.**
- **Particles in the molten state do not stress relieve.**
- **Lack of stress relief puts the coating layer in tension.**
- **Coating tension limits the coating layer thickness (the inherent tension becomes greater than the adhesion).**
- **Practical final coating layer thickness on calender rolls is .004” to .006” max.**
- **The intermittent burst application results in coating porosity that requires a sealer.**

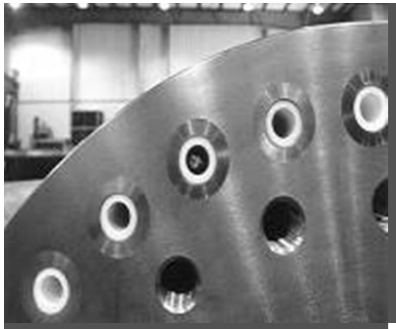


# HVOF Description

**The HVOF process efficiently uses high kinetic energy & controlled thermal output to produce dense, low-porosity coatings that exhibit high bond strengths (some exceed 12,000 psi), low oxides, and extremely fine as-sprayed finishes. The coatings have low residual internal stresses and can be sprayed to a thickness not normally associated with dense, thermal spray coatings.**

**As a result of the high kinetic energy transferred to the particles through the HVOF process, the coating material generally does not need to be fully melted. Instead the powder particles are in a semi-molten state and flatten plastically as they impact the work surface. The resulting coatings have very predictable chemistries that are homogeneous and have a fine grain structure.**

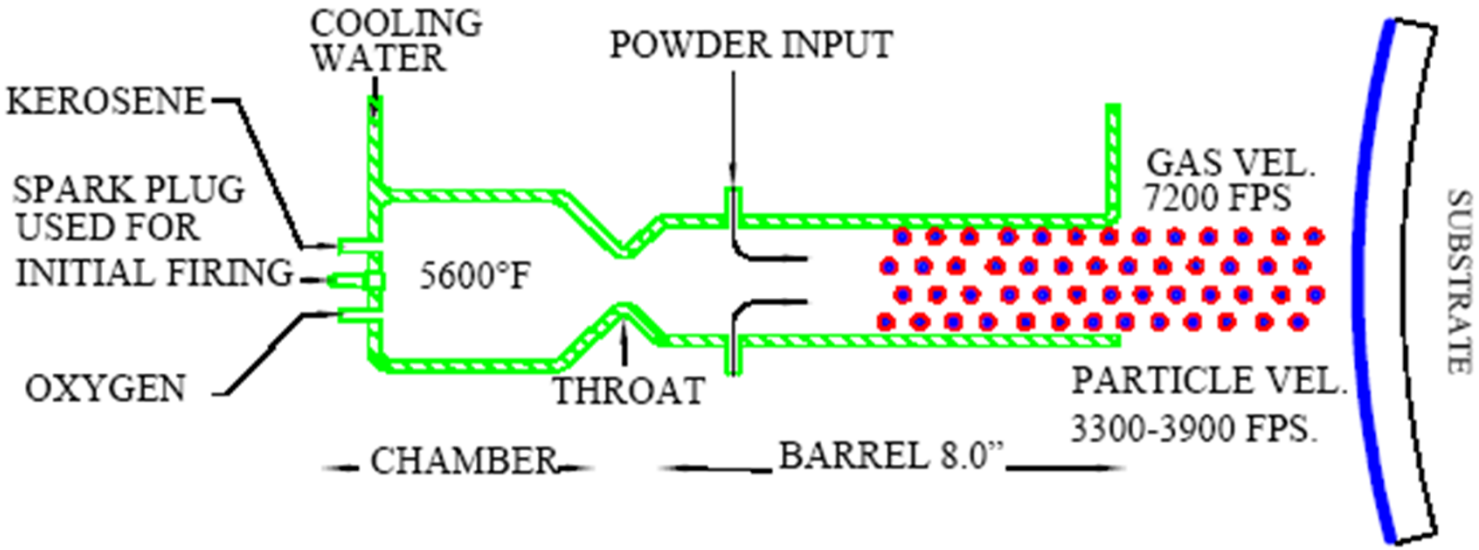
**Source: ASM Thermal Spray Society.**



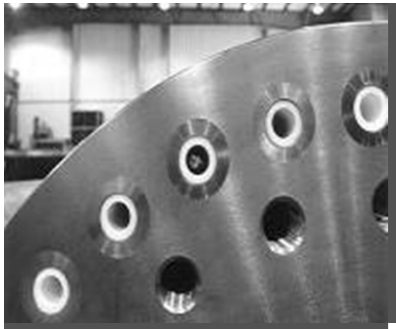
# Hard Coating Process

## HP/HVOF

### High Pressure/High Velocity Oxygen Fuel

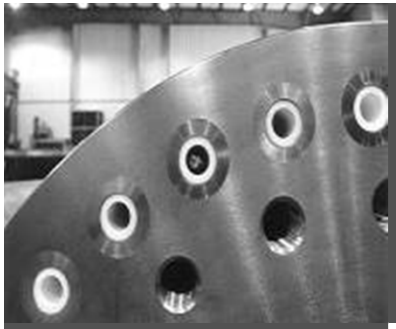



SHORTER BARREL = LESS DWELL TIME, LOWER PARTICLE TEMP. = LESS OXIDATION
PARTICLES IN COMPRESSIVE OR NEUTRAL STRESS
SEMI SOLID PARTICLES ACT TO STRESS RELIEVE PRIOR LAYERS (SHOT PEEN EFFECT)
PRODUCES A THICKER COATING DUE TO REDUCED STRESSES



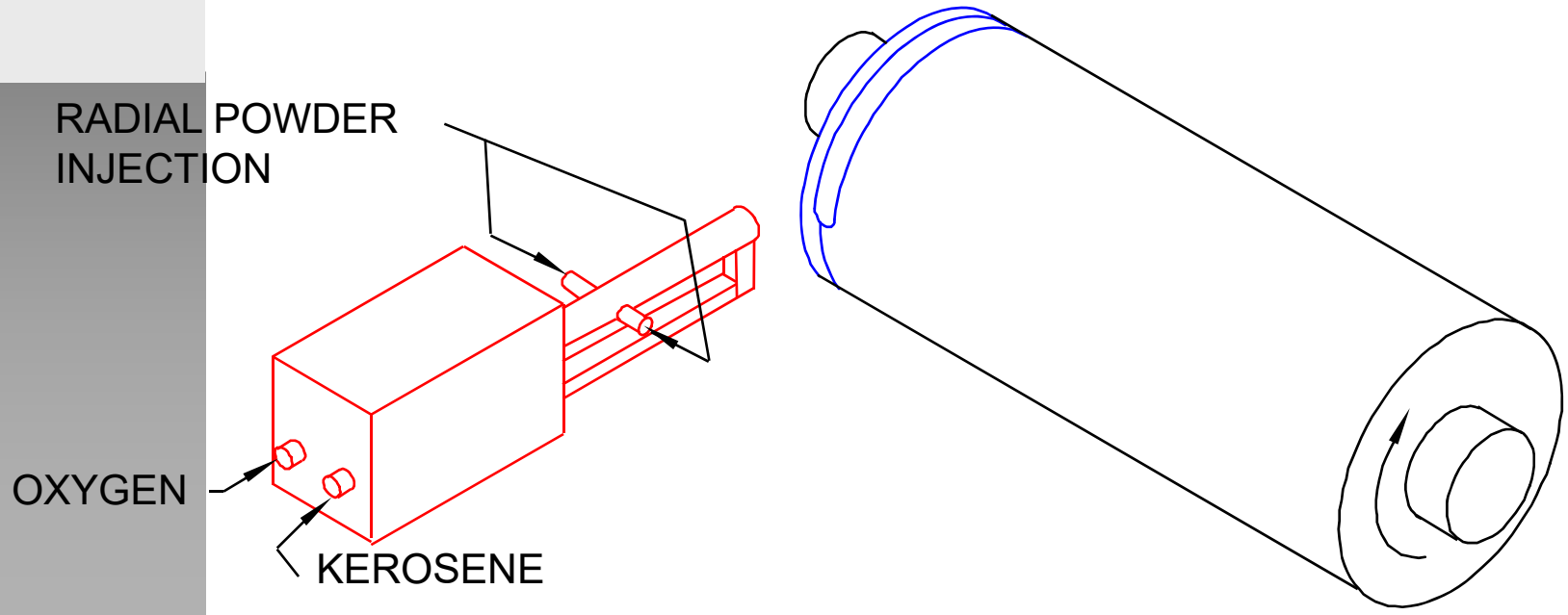
# What is “Compression”

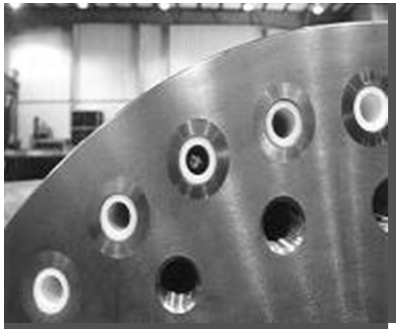
**“Compression” is application of balanced inward pushing forces to different points on a material or structure with no net sum or torque directed so as to reduce its size in one or more directions.**



# HP/HVOF Application

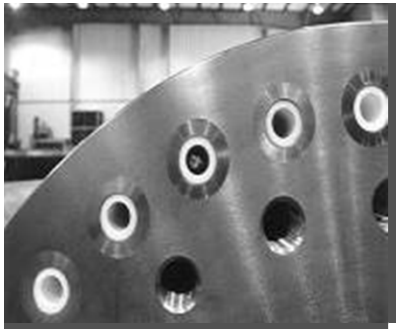
- **Continuous, uniform, overlapping spray.**
- **Even coating layer.**
- **No through porosity.**



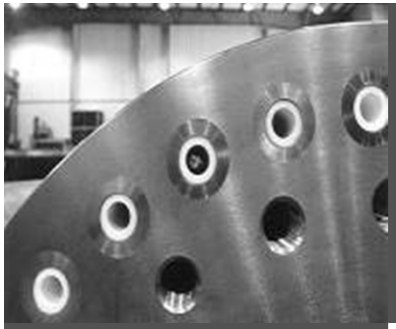


# HVOF Advantages

- **5600° F. application temp results in less particle oxidation & stress.**
- **Particles semi-solid at application: “shot-peen” stress relieving prior layers.**
- **Coating layer is in neutral or compressive stress enabling greater coating thicknesses.**
- **Uniform application with no porosity.**
- **Practical coating thickness on calender rolls is .008” to .014”, depending on roll surface.**
- **Thicker coating = longer time between re-coats = greater ROI.**

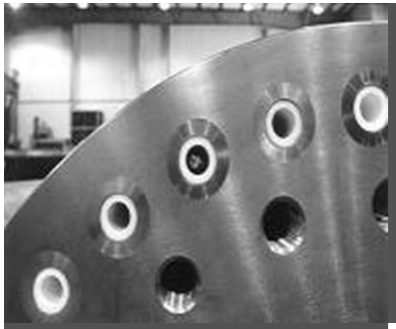


# Coating Spray Booth

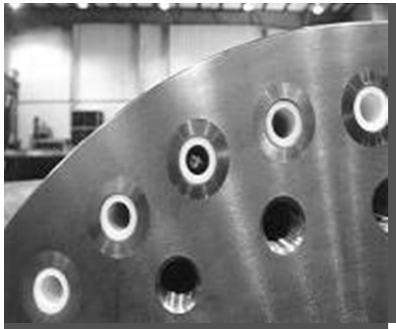


# Preparation for Coating

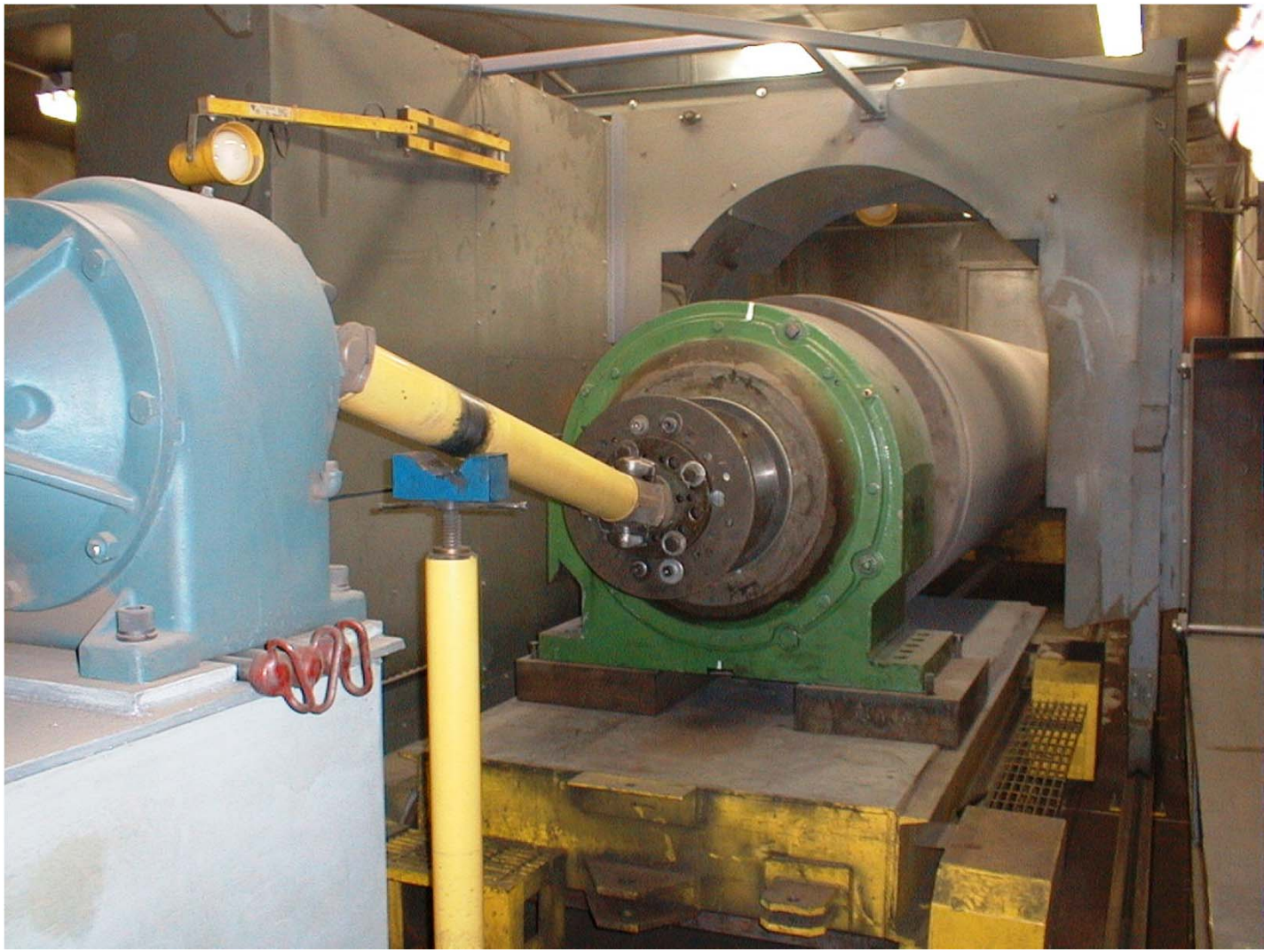
- **Thorough roll inspection**
- **Remove bearings & housings**
- **Precision roll grind for profile**
- **Measure & record profile & diameter**
- **Check roll balance – rebalance if required**
- **Grit blast roll surface for maximum coating adhesion.**

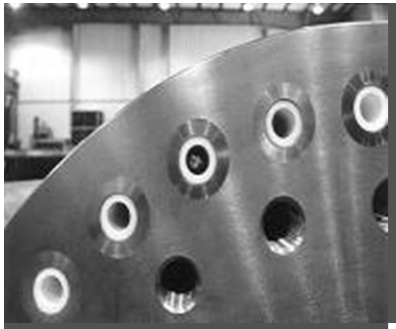


# Positioning Roll for Spraying



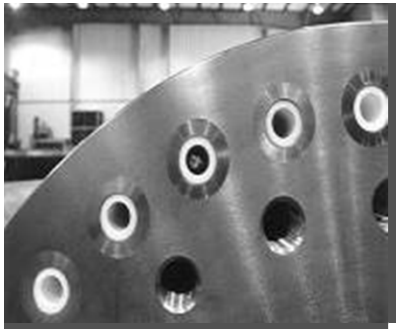
# Roll Drive Assembly



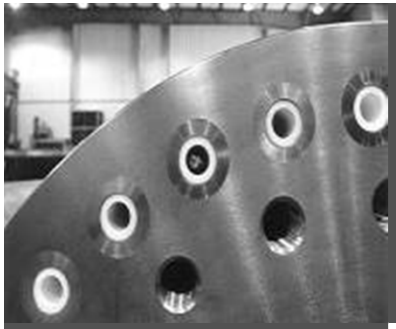


# Coating Quality Control

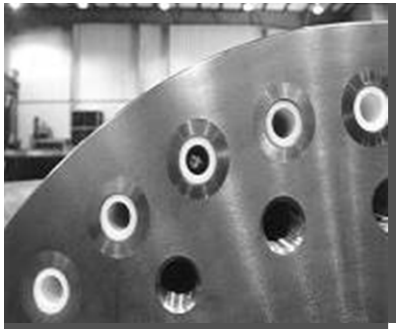
- **Performed on each lot of powder**
- **Powder flow test and metallographic evaluation to verify:**
  - **Particle size range**
  - **Density**
  - **Chemistry**
- **Spray test**
  - **30 minute minimum**
  - **Metallographic coupon**



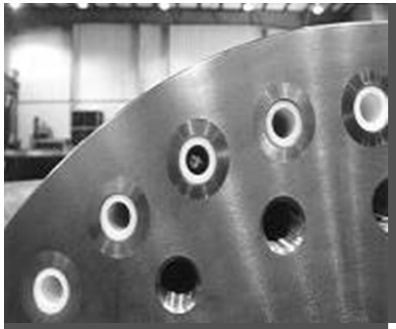
# Coating Control Booth



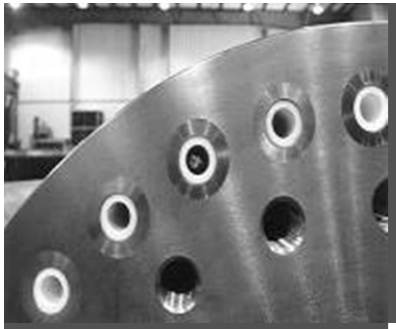
# Spray Application
## (Continuous Until Finished)



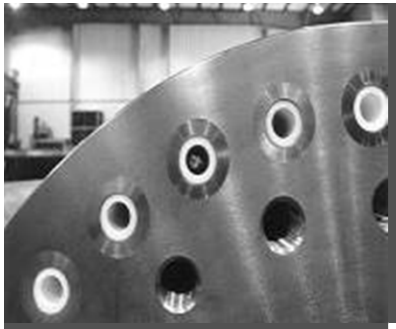
# Checked Between Passes



# .014” - .016” Applied



# Final Coating Layer Check



# Final Grind