Improving Mill Performance with Advanced Wear Protection Technologies

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2004 TAPPI Fall Technical Conference
Session 36, Corrosion Prevention
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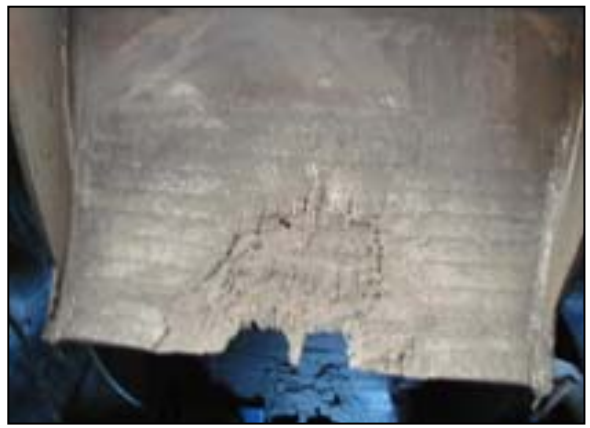
Introduction

Introduction

- Mill managers, engineers & maintenance personnel becoming accountable for
  - Increasing efficiency
  - Reducing downtime
  - Reducing operational costs
  - Complying with environmental standards

Introduction

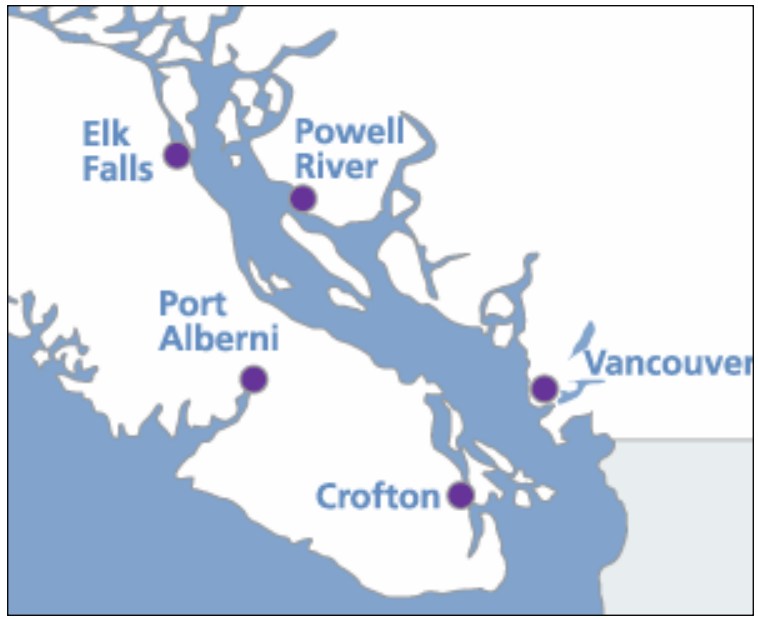
- Effects of severe corrosion and erosion
  - Expensive replacement equipment
  - Costly and inconvenient downtime
  - Reductions in mill productivity


NorskeCanada, Port Alberni Boiler ID Fan Erosion Testing

NorskeCanada

- One of North America's largest ground wood pulp & paper manufacturers
- Four mills & a paper recycling division in BC
  - Port Alberni
  - Crofton
  - Elk Falls
  - Powell River



NorskeCanada, Port Alberni

- Large producer of telephone directory & lightweight coated papers
- Annual paper production capacity of 432,000 metric tons
- Produces 480 metric tons of pulp each day using the CTMP method

NorskeCanada, Port Alberni

- Power boiler
  - 1978 Combustion Engineering Inc. with a converted Kvaerner fluidized sand bed
  - Steam capacity of 400,000 pounds/hour
  - Burns 900 metric tons of hog fuel a day

NorskeCanada, Port Alberni

- Induced Draft (ID) Fan
  - Manufactured by Baron Industries
  - 10 forward facing curved blades
  - 300 cm (10′) diameter fan wheel
  - 1,750 horsepower drive fixed to Liquid Flo fluid coupling
  - 800 RPM fan speed

NorskeCanada, Port Alberni

- Induced Draft (ID) Fan
  - Annual maintenance during required boiler outage
  - Extensive repairs to
    - Fan housing
    - Inlet dampers
    - Multiclone sections upstream

NorskeCanada, Port Alberni

- Induced Draft (ID) Fan
  - Mill addressed severe wear of the fan to
    - Lengthen fan life from one to two years
    - Reduce operational and maintenance costs
    - Minimize shutdown periods associated with fan overhaul

Severe Wear of Boiler ID Fan

- Began experiencing severe wear in 1997
  - Boiler converted from stoker grate to fluidized-bed system
  - Forced to increase speed to achieve optimum capacity
  - Erosive fly ash wore outer portions of blade

Severe Wear of Boiler ID Fan

- Chrome carbide weld overlay protected fan prior to 2001
  - Decrease in capacity detected after 8 months in operation
  - Fan speed increased to maintain capacity
  - After 10 months, productivity losses exceeded ability to compensate with increased speed

Severe Wear of Boiler ID Fan

- Chrome carbide weld overlay protected fan prior to 2001

Fan blades protected with chrome carbide weld overlays after 12 months in operation

Severe Wear of Boiler ID Fan

- Chrome carbide weld overlay protected fan prior to 2001
  - Unable to achieve required boiler loading for the remaining two months (until planned outage)
  - Forced to burn more costly natural gas in second boiler
  - $150,000 in added fuel costs over two month period

Potential Wear Solutions

- June 2001 – Initiated testing of protective materials
  - Attached 102 mm (4″) x 254 mm (10″) material samples to fan housing scroll
    - Infiltration Brazed Tungsten Carbide Cladding
    - Chrome Carbide Weld Overlay
    - Hard Alloy Steel
  - Monitored for erosion performance for 6 months

Potential Wear Solutions

- Chrome Carbide Weld Overlay
  - Mild steel base with chromium carbide weld layer
  - Advantages
    - Moderately formable backing
    - Welded directly onto existing components
    - Applied & repaired on-site
    - Inexpensive

Potential Wear Solutions

- Chrome Carbide Weld Overlay
  - Disadvantages
    - Material check cracking
    - Channeling
    - Uneven application creates cracks between welds
    - Overlay distortion from intense heating & cooling of welding process causes spalling & breaking
    - Material pre-heating, post-heating, slow cooling & stress relieving may be needed

Potential Wear Solutions

- Wear Resistant Alloy Steel
  - Heat treatable, low alloy steel with low sulfur content
  - Advantages
    - Moderately formable backing
    - Welded directly onto existing components
    - Applied & repaired on-site
    - Inexpensive

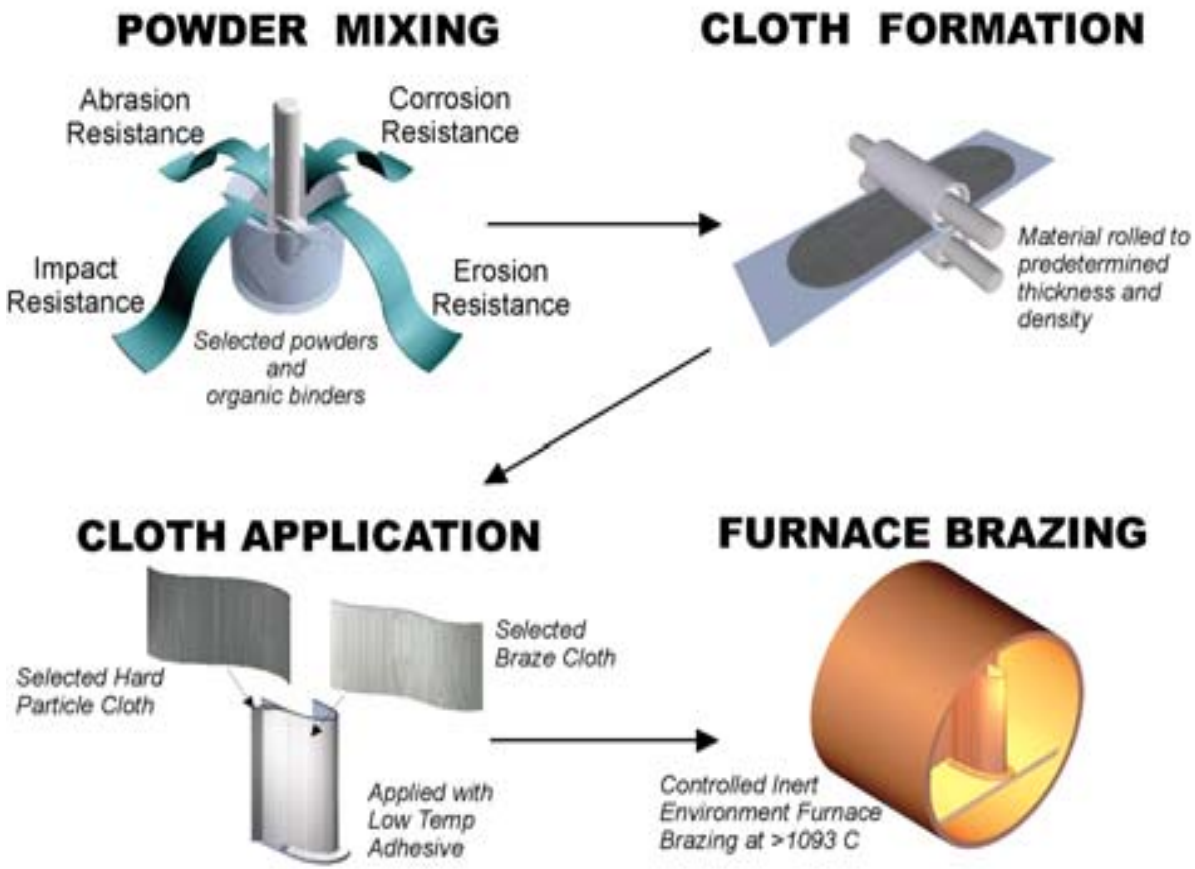
Potential Wear Solutions

- Wear Resistant Alloy Steel
  - Disadvantages
    - Protection in extreme environments is limited
    - Field applied steel plates susceptible to check cracking
    - Check cracking can propagate into base material & weld, causing possible fan failure

Potential Wear Solutions

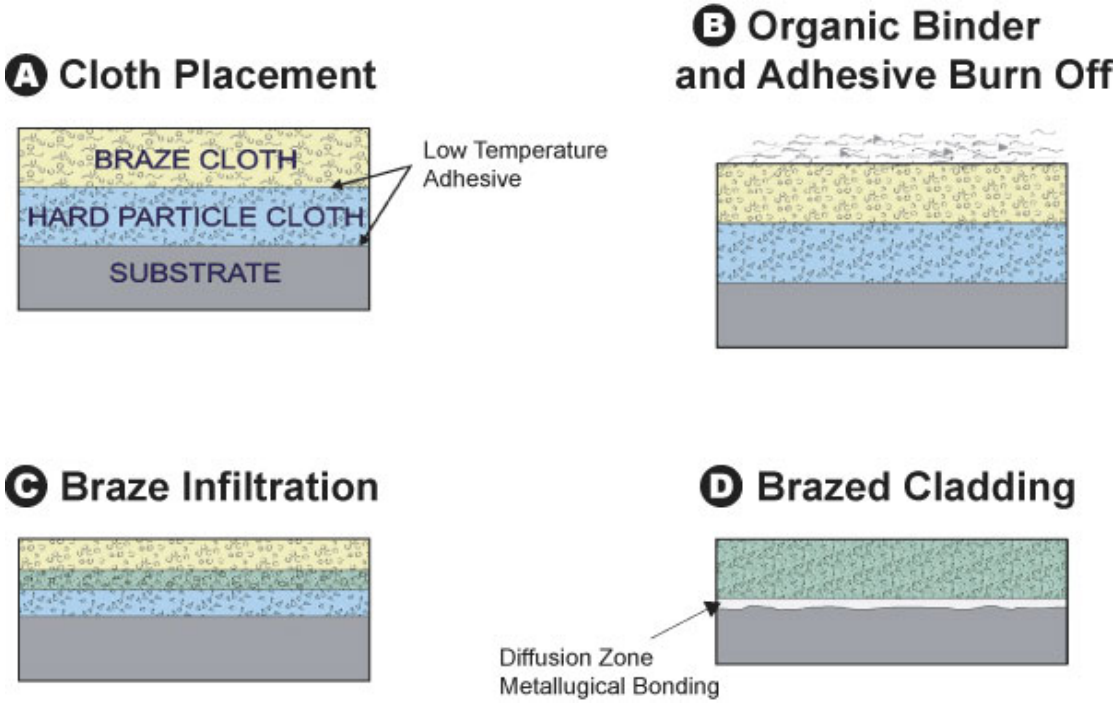
- Infiltration Brazed Tungsten Carbide Cladding

Process metallurgically bonds hard particles and matrix metal to substrate



Potential Wear Solutions

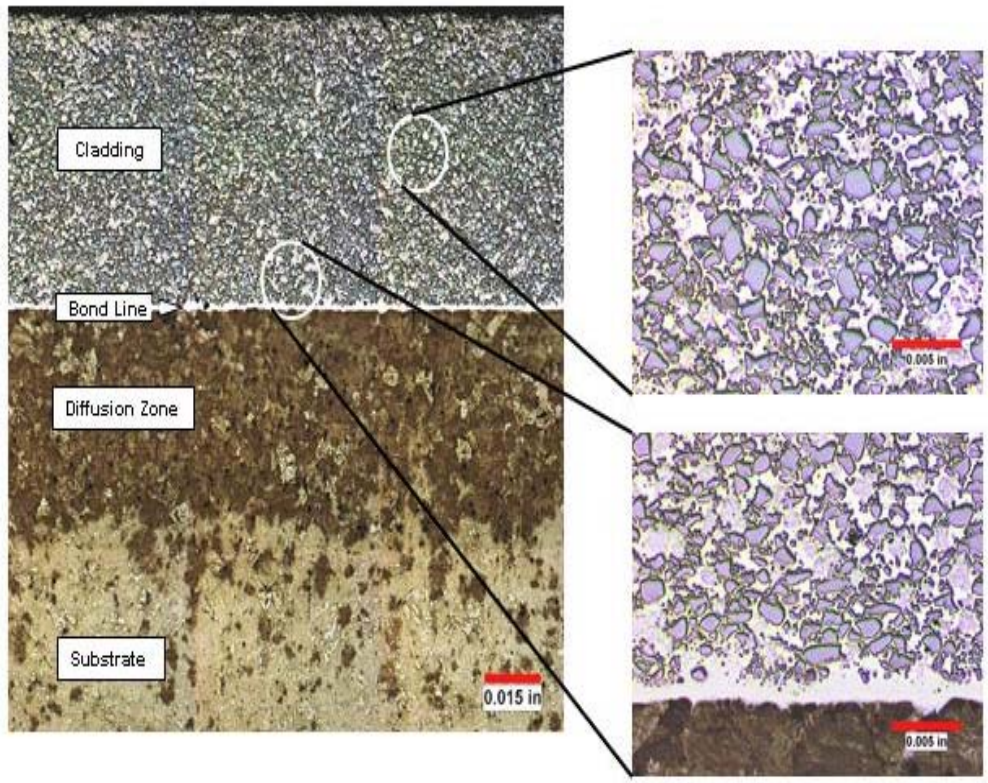
- Infiltration Brazed Tungsten Carbide Cladding
  - Infiltration brazing



Potential Wear Solutions

- Infiltration Brazed Tungsten Carbide Cladding

- ✓ **70+% W-C loading**
- ✓ **72+ Rockwell C**
- ✓ **70 – 120 KPSI Bond Strength**
- ✓ **Operation up to 1,922°F**



Potential Wear Solutions

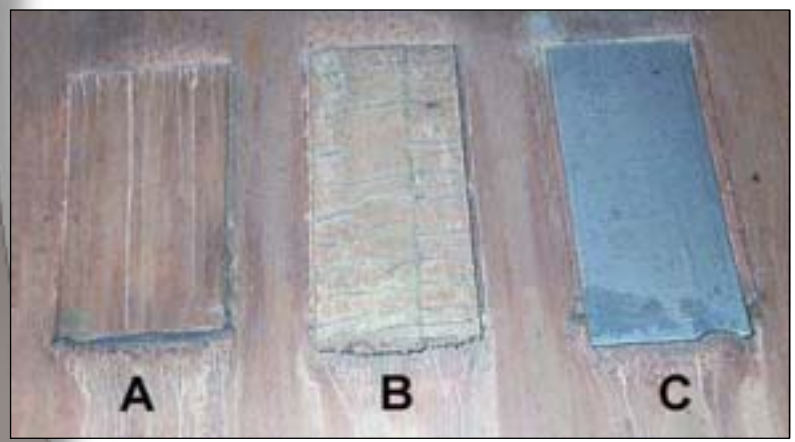
- Infiltration Brazed Tungsten Carbide Cladding
  - Advantages
    - Metallurgical bond
    - No interconnected porosity
    - No spalling, chipping
    - No check cracking
    - Linear, predictable wear

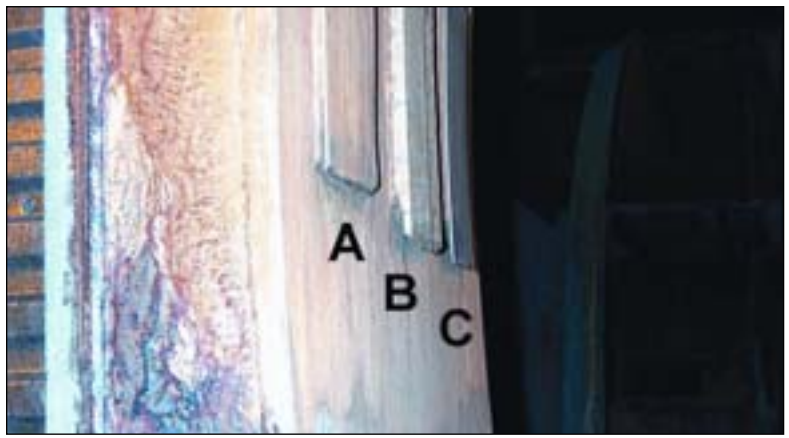
Potential Wear Solutions

- Infiltration Brazed Tungsten Carbide Cladding
  - Disadvantages
    - Cladding can not be field applied
    - Size limitations on pieces clad
    - Higher initial installation cost

Potential Wear Solutions

- Test Results – December 2001
  - Infiltration brazed tungsten carbide cladding performed best
    - Only material to retain original length





A=Alloy Steel, B=Chrome Carbide Weld Overlay,
C=Brazed Tungsten Carbide Cladding

Brazed Tungsten Carbide Cladding Application

- July 2002 – Port Alberni clad ID Fan A with brazed tungsten carbide cladding
  - Ten 838 mm (33″) x 445 mm (17 ½″) fan blade liners
  - Protected with 1.5 mm (0.060″) of cladding

Brazed Tungsten Carbide Cladding Application

- Fan maintained optimal capacity for 12 months of continuous operation
  - Wear zone detected in middle of leading edge

Wear on Fan A after 12 months in operation

Brazed Tungsten Carbide Cladding Application

- July 2003 – expanded application to auxiliary fan (Fan B)
  - Blades & areas on center of support web
    - Ten 838 mm (33″) x 445 mm (17 ½″) fan blade liners
    - Ten 1067 mm (42″) x 241 mm (9 ½″) fan blade liners
    - Ten 503 mm (19 13/16″) x 584 mm (23″) fan rib plates
    - Twenty 287 mm (11 5/16″) x 451 mm (17 ¾″) fan side plates

Brazed Tungsten Carbide Cladding Application

- July 2003 – expanded application to auxiliary fan (Fan B)
  - Protected with 1.5 mm (0.060″) of cladding
- Fan maintained optimal capacity for 12 months of continuous operation

Wear on Fan B after 12 months in operation

Brazed Tungsten Carbide Cladding Application

- June 2004 – expanded Fan A application
  - Ten 838 mm (33″) x 445 mm (17 ½″) fan blade liners
  - Ten 1067 mm (42″) x 241 mm (9 ½″) fan blade liners
  - Ten 503 mm (19 13/16″) x 584 mm (23″) fan rib plates
  - Twenty 287 mm (11 5/16″) x 451 mm (17 ¾″) fan side plates

Brazed Tungsten Carbide Cladding Application

- June 2004 – expanded Fan A application
  - Installed next generation 838 mm (33″) x 445 mm (17 ½″) liners
    - Entire liner clad with 1 mm (0.040″) application
    - High wear zone received an additional 1 mm (0.040″) of cladding
  - Double-clad liner expected to last two years (due to predictable wear rate)

Brazed Tungsten Carbide Cladding Application

- Application Results
  - It's anticipated that the mill will begin replacing ID fans once every other year, instead of annually
    - $150,000 biannual savings in maintenance costs
  - Significant productivity and opportunity savings

Independent Comparison Data

Independent Comparison Data

- EPRI/TVA Kingston Power Plant Study
  - Tested the effects of erosion on popular wear resistant materials applied to power boiler ID fans (1)
  - Initiated in Fall 2001, 60 day trial period
  - Tested 16 wear protected fan blades from 6 commercial suppliers

1 EPRI. *TVA Kingston Fossil Plant – Induced Draft Fan Erosion.* Palo Alto, California: Electric Power Research Institute Report, ER&TA Number 021807, May 2002.

Independent Comparison Data

- EPRI/TVA Kingston Power Plant Study
  - Materials tested
    - Infiltration Brazed Tungsten Carbide Cladding
    - Tungsten Carbide HVOF (from 2 suppliers)
    - Tungsten Carbide Plasma Spray
    - Tungsten Carbide Manual Spray with Post-Spray Furnace Fuse
    - Chrome Carbide Weld Overlay

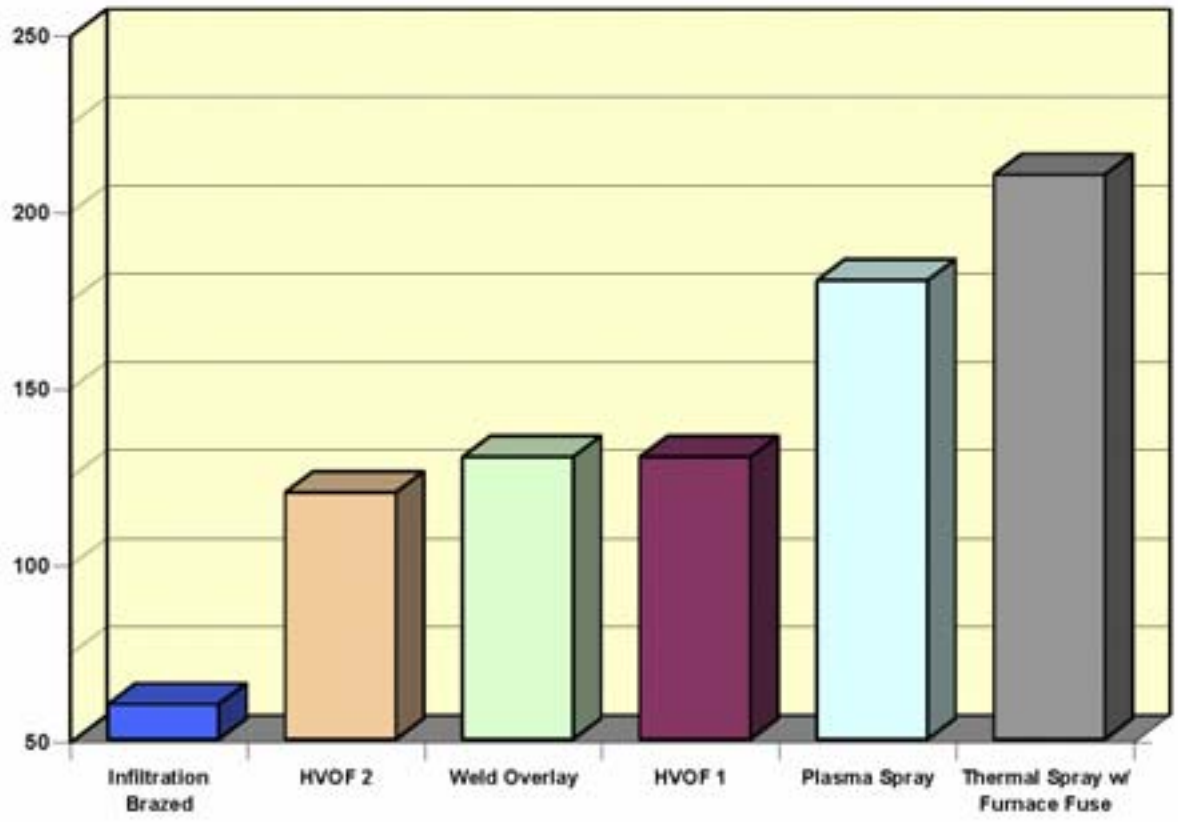
Independent Comparison Data

- EPRI/TVA Kingston Power Plant Study
  - ID Fan
    - Double inlet, single exhaust
    - 400,000 CFM Westinghouse model 16MVID
    - Forward curve fan blades
    - 120 blades per fan
    - Shaft speed = 593 PRM

Independent Comparison Data

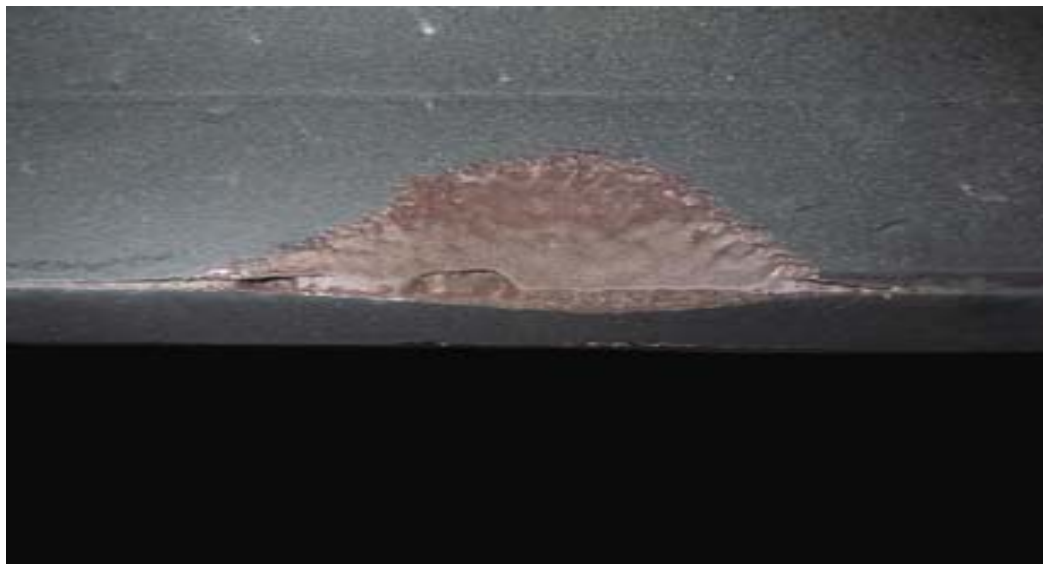
- EPRI/TVA Kingston Power Plant Study
  - Test Results

Wall loss
after 69 days



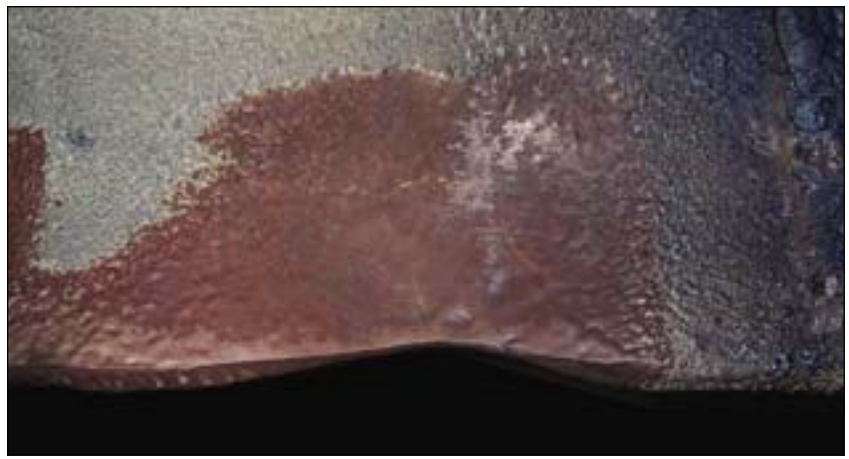
Independent Comparison Data

- EPRI/TVA Kingston Power Plant Study
  - Test Results
    - Tungsten Carbide HVOF



Independent Comparison Data

- EPRI/TVA Kingston Power Plant Study
  - Test Results
    - Tungsten Carbide Plasma Spray
      - complete wear through
    - Tungsten Carbide Manual Spray with Post-Spray Furnace Fuse



Independent Comparison Data

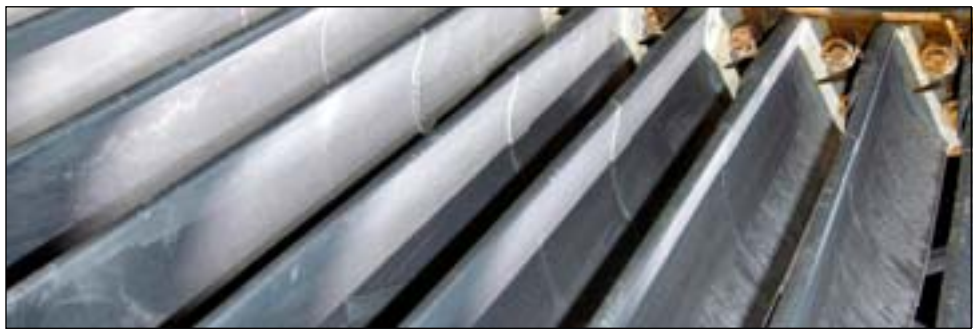
- EPRI/TVA Kingston Power Plant Study
  - Test Results
    - Chrome Carbide Weld Overlay
      - Material loss of 3 mm (0.12″)
      - Crack at center of junction plate

Independent Comparison Data

- EPRI/TVA Kingston Power Plant Study
  - Test Results
    - Infiltration Brazed Tungsten Carbide Cladding
      - Material loss of .25 mm (0.010″) at leading edge

Independent Comparison Data

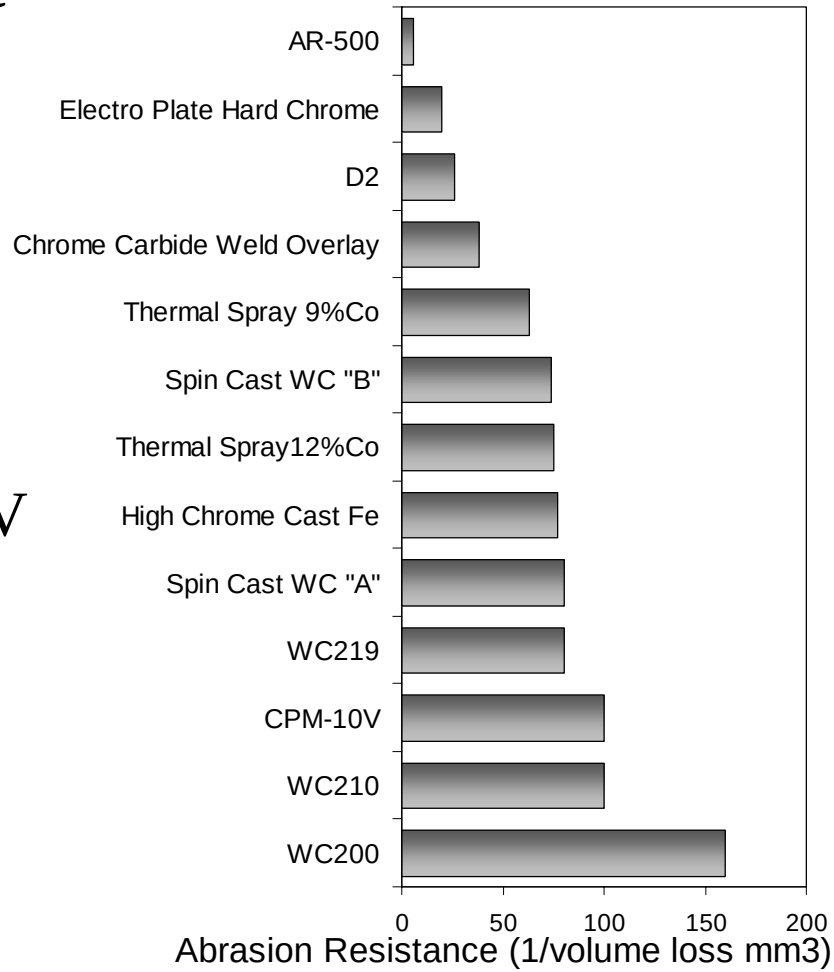
- EPRI/TVA Kingston Power Plant Study
  - Kingston installed ID fan blades clad with brazed tungsten carbide in boiler Units 5-9
    - Blades installed October 2002
      - After 7 months run time, blades showed material loss of .4 mm (0.014″) or less.
    - Expected life > 24 months
      - Four times life of unprotected fans



Standardized Testing

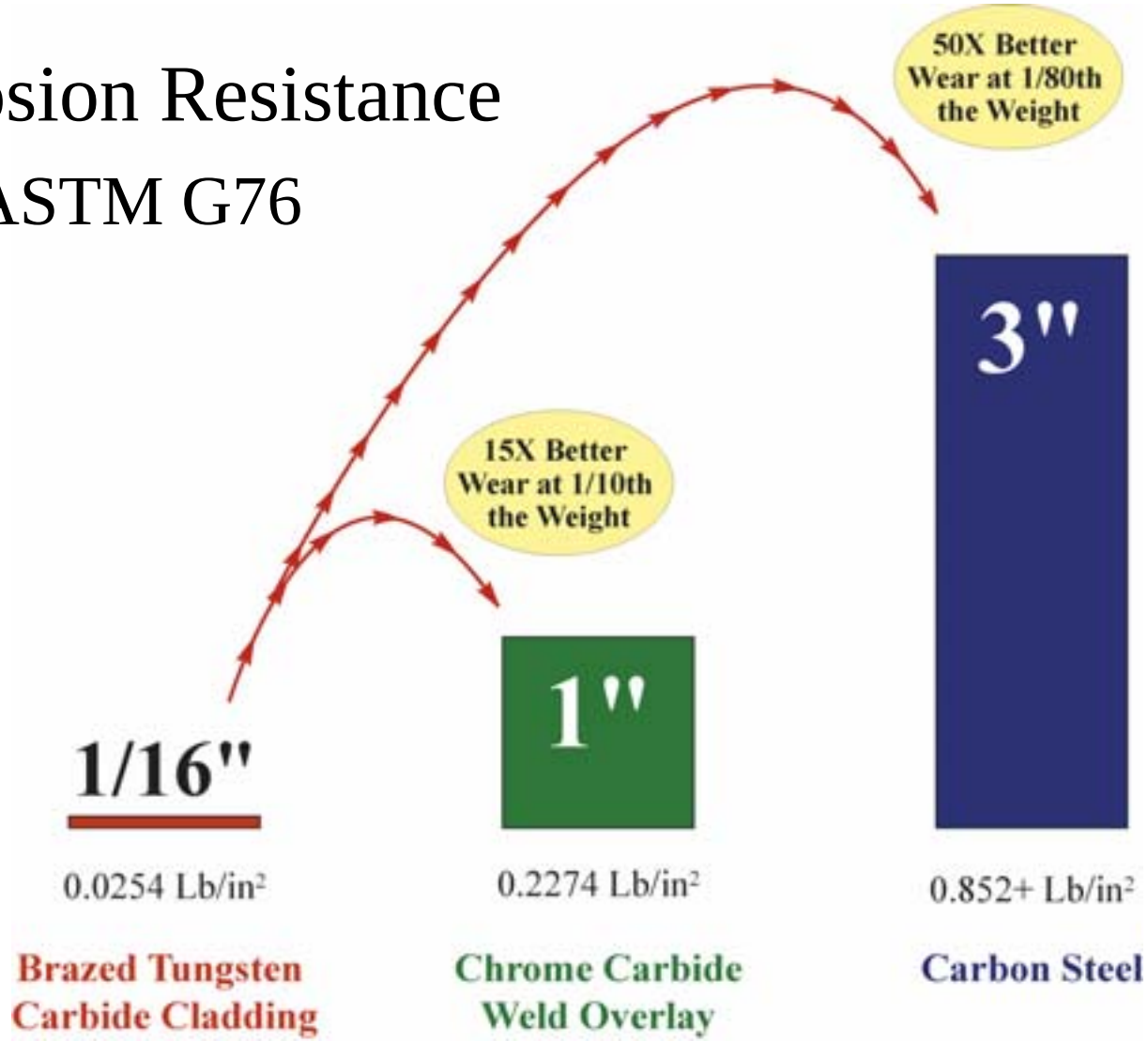
Standardized Testing

- Abrasion Resistance
  - ASTM G65
    - Sand abrasion measures volume loss (mm^3), ΔV
    - Abrasion Resistance Factor (ARF) = $1/\Delta V$
    - Test conditions: 6000 rev, 30 lb



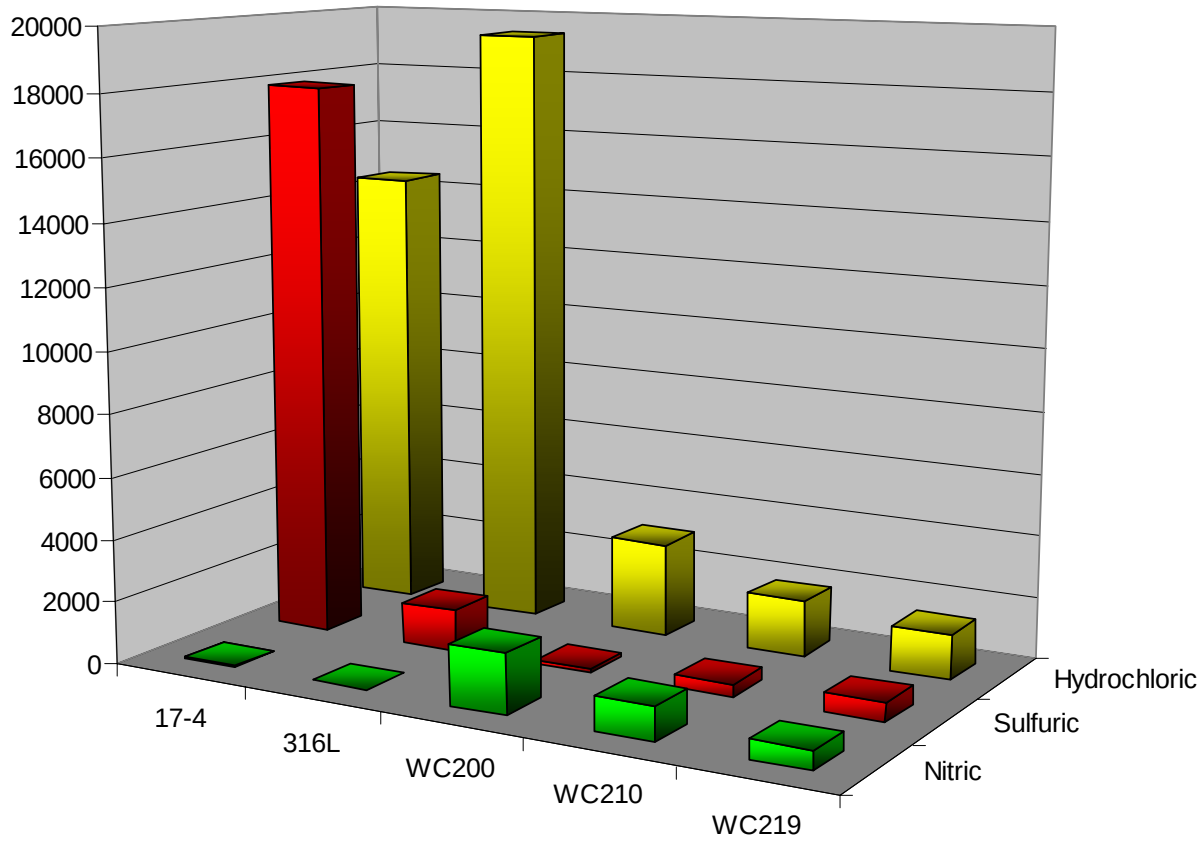
Standardized Testing

- Erosion Resistance
  - ASTM G76



Standardized Testing

- Corrosion Resistance
  - ASTM G31



Real World Applications

Real World Comparisons

- Power Generation - high velocity burner application - under severe erosion and thermal shock
  - Thermal shock range from 2,000°F to 800°F
  - Coal velocity ~ 87 fps
  - Coal + petroleum coke: 9%
  - Ash comprised of 80% Silicon Dioxide and Aluminum Oxide

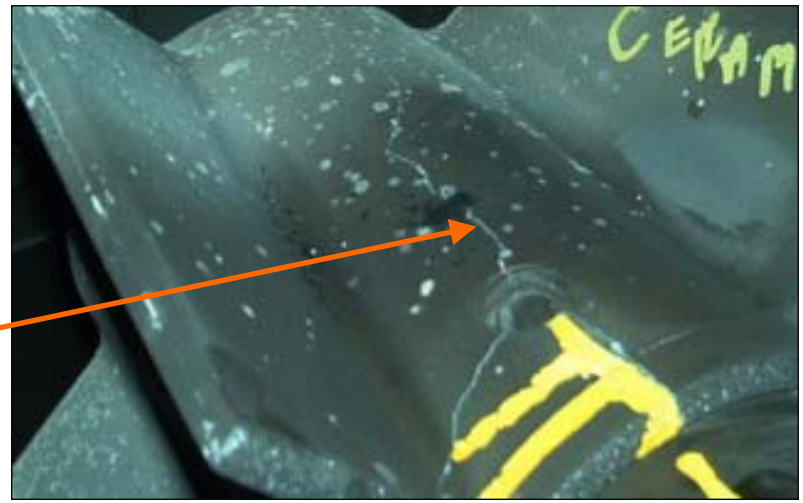
Real World Comparisons

- Power Generation - high velocity burner application - under severe thermal shock
  - Burner component coated with Stellite 6 experienced 38 mm (1 1/2″) of erosion from leading edge after 22 months service

Real World Comparisons

- Power Generation - high velocity burner application - under severe thermal shock
  - Ceramic cast burner experienced 1.8 mm (0.070″) erosion and significant cracking
    - Ceramic disintegrated during burner disassembly

Note cracking of ceramic spreader



Real World Comparisons

- Power Generation - high velocity burner application - under severe thermal shock
  - Maximum material loss of infiltration brazed tungsten carbide clad component was only .2 mm (0.007″)

Real World Comparisons

- AEP/CINERGY Zimmer Power Station, Unit 2, Gas Recirculation Fan
  - Infiltration brazed tungsten carbide cladding extended runtime between outages from 14 months to more than 3 years

Real World Comparisons

- AEP/CINERGY Zimmer Power Station, Unit 2, Gas Recirculation Fan

Vanadium Carbide Weld Overlay After 14 Months
(19 mm (¾″) eroded from leading edge)

Brazed Tungsten Carbide Liner After 14 Months
(no visible wear)

Other Mill Applications

- Worthington 90 cm (3′) x 60 cm (2′) white liquor slurry pump
  - 45% Solids, 14 pH
  - Life with stainless steel protection = 6 months
  - Brazed tungsten carbide cladding increased life to > 13 months
  - Predicted life of clad pump > 36 months

Other Mill Applications

- Worthington 90 cm (3′) x 60 cm (2′) white liquor slurry pump
  - After 6 months in operation
    - No detectable wear on internal surfaces
    - .1 mm (0.005″) wear on 45° chamfer & on impeller tips

Other Mill Applications

- 900 cm (30′) lime kiln feed screw
  - Protected with chrome carbide weld overlay
    - Useful life of one year with weld repairs every 6 months
    - With infiltration brazed tungsten carbide, useful life increased to over 2 ½ years

Conclusion

- Infiltration brazed tungsten carbide cladding outperforms other wear protection materials in highly erosive power boiler environments
  - Reduces operating & maintenance costs
  - Reliably extends planned outage cycles
  - Reduces risk of unscheduled downtime
- NorskeCanada, Port Alberni exploring additional applications
  - Hog & chip handling equipment
  - Ash conveyance

Questions

Click here to learn more about Conforma Clad severe wear solutions.