CHROME PLATING ALTERNATIVES FOR ROLLS

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WARNING!

- Our expertise is coatings and surface treatments
- Your expertise is rolls
- There is very little available information on the use of coatings for work rolls (which in itself says a lot)
- Let’s put our heads together and see what solutions there are
- Don’t take anything I say as gospel!
Unless you have a job like this, some part of your life relies on chrome plating
“THE REPORTS OF MY DEATH ARE GREATLY EXAGGERATED” – MARK TWAIN

- There is a perception that hard chrome plating is being drummed out of existence
- Cr$^{6+}$ is under pressure from EPA air emission regs and OSHA PEL
  - But there is no imminent move to ban chrome plating or make it impossible
  - It is likely to be around for a long time yet
HARD CHROME IS LIKE ALLSPICE

When you replace it with something else things get more complicated
The result is usually a lot better, and certainly more interesting!
But not always:

Which is why my wife keeps me away from the spice cabinet
WHAT ARE THE OPTIONS FOR REPLACING HARD CHROME?

- HVOF (High Velocity Oxy-Fuel) spray is the method of choice
  - Used for many types of rolls, large and small
  - Hydraulic actuators for mining vehicles, aircraft landing gear
- Other electroplates
- Vapor deposition coatings
  - Nitrides, diamondlike carbon
- Heat treatments
- Laser cladding
WHAT REALLY MAKES SENSE FOR ROLLS?
WHY HARD CHROME?

- Because it is AllSpice
- It works very well
  - Hard, low wear (600-800VHN)
  - Can be very thin (0.0001”)
  - Very good adhesion
  - Easy to do
  - Can plate very large roll in reasonably short time
WHAT IS THE REAL PROBLEM WITH HARD CHROME?

- From EPA data back in mid 1990’s

Risks:
- Cr\textsuperscript{6+} is a carcinogen and has various serious health concerns
- EPA, OSHA violations, fines
- Long term legal liability for worker health and safety, waste disposal, soil contamination, etc.
- Steadily increasing cost of compliance
WHY DO CHROME PLATERS WORRY?

- Nobody wants to be pursued by this lady
ROLLS IN GENERAL

- HVOF and plasma spray coatings widely used for industrial rolls
  - Guide rolls
  - Cradle rolls
  - Tensioning rolls
  - Bridle rolls
  - Deflector rolls
  - Anilox print rolls
  - Yankee drier rolls (paper)
  - Note – most of these are not high stress

- Much harder and more wear resistant than chrome
  - Holds surface profile
WHAT IS HVOF THERMAL SPRAY?
HVOF FOR WORK ROLLS

- Praxair patent application 2007/0261767 A1
  - HVOF WC-CoCr 0.001-0.010” thick on work rolls for Al
  - What about work rolls for steel?
- Problem is that work rolls are high stress, especially for steels
  - Rolling contact fatigue
  - Thermal sprays generally not good under high RCF
  - Tend to crack and delaminate
- Cost typically ~$2,000/roll – 10 times chrome plate
  - But wear resistance much better than chrome (very hard, 1,500VHN)
- Are there better options?

Expect much better performance but much higher cost

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ALTERNATIVE ELECTROPLATES

- Nanophase coatings by pulse plating
  - Co-P from Integran
  - Ni-W from Xtalic
  - Similar/somewhat better wear resistance to chrome
  - Size limitation determined by available power supplies
  - Best hardness requires >500F heat treat (~600VHN, 900+VHN heat treated)

- Co-Cr$_3$C$_2$ and similar composites
  - Available from Praxair and US Hard Chrome
  - Similar/somewhat better wear resistance to chrome
  - Minimum thickness > particle size
  - Best hardness requires heat treat

- Cost/performance may or may not be worthwhile

Cost-benefit compared with hard chrome not known
Expect similar/maybe better (?) performance at higher cost
VAPOR DEPOSITION

- Really good, hard (2,500VHN), thin coatings (typically 0.0001”)
- Surface finish same as original surface
- Very wear resistant, used for bearings (rolling cycle fatigue)
- But
  - Expensive
  - Difficult to find a coater with a big enough chamber
  - This is a really BIG industrial system
  - Could build a special system ~$5million

Expect much better performance but much higher cost, no rebuild
Not a practical approach for rolls

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LASER CLADDING

- Usually used to add hard metals
- Can be used to deposit WC-Co
- Very thick build – typically >0.04” thick
  - Expensive
- Slow for a large roll

Expect not practical or cost-effective for large rolls
WHICH BRINGS US BACK TO THERMAL SPRAY

- The best material (WC-CoCr) is very expensive
- Cheaper options not as wear resistant but may be adequate
  - E.g. Cr$_3$C$_2$-NiCr
- There is also a trade-off between hardness and fracture toughness
- Another approach is to make the coating very thin (\(<0.001\)”) so cheaper and better RCF
  - But thin coatings are poor quality and not continuous
- Might overcome this with very fine or nanograin powder or with solution thermal spray
  - “Poor man’s CVD”
MAYBE WE CAN CHANGE THE COST MODEL

- Suppose thermal spray coating cost 10 times as much but lasted 10 times as long
  - How much better must it work to be worth the added cost?
  - Worth it provided you could be sure it would work as advertised
  - More than worth it if less frequent rework, fewer rolls needed in inventory
- Who is going to take the risk and do the testing to see whether the economics make it a practical solution?
A POSSIBLE WAY FORWARD

- The only reasonable alternatives are thermal spray (not necessarily standard) or electroplates
- It might make sense to do what other industries have done (such as aircraft industry HCAT program)
  - Treat as precompetitive technology
  - Form a team
  - Pool resources, carry out testing for several options
  - Share results across team membership
- Beware! It is not that hard to reverse-engineer!