Failure of Smelt Spouts in Kraft Recovery Boilers

Pulp and Paper Corrosion Symposium

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What are smelt spouts?
Why do we care if they fail?

- Potential source for introduction of cooling water into the lower-furnace section of recovery boiler & smelt stream

- Could trigger a smelt-water explosion capable of destroying the boiler

- Significance manifested through published set of recommendations for proper smelt cooling system design, operation & maintenance

- BLRBAC suggests annual replacement
  - Ensures that failures are rare, but
  - Major barrier to extending maintenance outages
Industry lacks fundamental understanding of cause of failures

- Most spouts are made from carbon steel; cheap & replaceable
  - Some can last many years
  - Some stagger to the finish line with serious damage
  - A few fail in less than 6 months
  - Uncertainty about state of spouts in operation makes it difficult to assess risk

- Many different damage mechanisms
  - Fabrication defects
  - Design flaws
  - Cooling water failures
  - Mechanical damage
  - Corrosion/erosion
  - Corrosion fatigue/thermal fatigue
Preventative measures adopted include:

- Changing spout design
- Chromizing
- Construction from alternative alloys (Alloy 625)
- Non-cooled (dry) spouts [Ni-(45-50 wt.% Cr Alloy]
- Thermal spray coatings
- Weld overlays

But no solution effective in all mills!
Fabrication Defects

- 1999 B&W 1525 psig unit; membrane construction (2½" tubes on 3" centres); sloped floor
- Leaked after about 80 days of service
Cross-Section Examination

Corroded "G" Section

Corroded "E" Section

SMELTSIDE

Inner Trough Plate

WATERSIDE

End Plate

WATERSIDE

End Plate

Weld
Microstructure Examination

End Plate

Well-Defined Pearlite

Weld Nugget

Centreline Crack
Key Findings

• Overheating ruled out as critical factor
  ▪ No evidence of pearlite spheroidization found in microstructure of corroded carbon steel end plate

• Questionable fabrication is a factor
  ▪ Evidence of undersized weld nugget
  ▪ Evidence of centreline cracking (a common weld defect resulting from poor fit-up, overly rigid fit-up, or a small ration of weld metal to base metal)

• Unidentified nitrogen-containing compound on corroded surface
Chromized Spouts

- Installed as replacement upgrade
Cross-Section Examination

- Corrosion was found on the inner trough plate and the end plate after about 12 months of service
Key Findings

- Chromizing treatment was likely not suitably done or the surface was not properly prepared for chromizing
- Chromium-rich surface layer did not provide sufficient protection for this smelt spout

Ideal treatment features
- Kirkendall voids near surface
- Fairly uniform thickness
Alloy 625 Spouts

- Alloy 625 inner trough plate; carbon steel end plate
- Inserted as replacement upgrade
- Leaked in less than twelve months service
Change End Plate Metallurgy!

- Leaks occurring in end plate, underneath smelt flow
- Spouts weld-overlaid with Alloy 625 available for service (inner trough plate and end plate)
But that might not work either; Alloy 625 weld overlaid spouts

- Leaks after less than twelve months service
Another spout with a IN625 end plate
Thermal spray coating was then applied to trough and end plate to prevent corrosion.
IN690 weld overlay was applied to address issues with 625 solid plate
Failure occurred at interface between weld overlay and carbon steel
What kind of environment do the spouts live in?

- Hot flowing smelt over the surface of the trough
- Extreme variations in flow rate (from plugging to smelt rushes)
- Insufficient cooling water flow
- Boiling of cooling water under trough plate
- Enclosed space inside the hood
- Moisture and chemicals from shatter jets
- Moisture and chemicals from hood washdown sprays
More systematic study of environment and operation required
What do we know about how the spouts operate?

IR pyrometers measure temperature of flowing smelt in spout; a video camera is also aimed at a spout to correlate visual appearance with temperature events.
Monitoring temperature of smelt flowing out of spouts in one boiler

- Dry spout
- Crusted smelt layer
- Crusting spout
- Example of rodding event
Concluding Remarks and Comments

• Spouts operate in a difficult environment

• Quality control during fabrication is important

• Metallurgical solutions may buy time but don’t always solve problems

• Ad hoc solutions often introduce new problems

• Consider spout environment
  ▪ Avoid water condensation on spout surfaces (from hood washdown sprays, shatter jets)
  ▪ Investigate how boiler operation impacts spout environment (air system set up, liquor firing)
Thank You
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