The Viscosity of Recovery Boiler Smelt

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Viscosity

- An important parameter in determining
  - the fluidity of smelt
  - the slagging behavior of deposits in waterwall tubes and superheater tubes
- Expected to be a function of composition and temperature
- Difficult to measure due to corrosive nature of molten smelt
- Limited data available in literature
Experimental Apparatus

- Viscometer
- Rotary Transducer
- Spindle
- Thermocouple
- N₂ Purging
- Alumina Crucible
- Smelt
- Stainless Steel Retort
- Furnace
Na$_2$SO$_4$ – NaCl Melts

Viscosity (cP)

Temperature (°C)

550 600 650 700 750 800 850

20 mole% NaCl

50 60 40 70 80
**Na$_2$SO$_4$ – NaCl Phase Diagram**

Synthetic Melts Examined

- 19 melts
  - 7 NaCl-Na$_2$SO$_4$ mixtures
  - 3 NaCl-Na$_2$CO$_3$ mixtures
  - 3 Li$_2$CO$_3$-Na$_2$CO$_3$ mixtures
  - 3 NaOH-Li$_2$CO$_3$ mixtures
  - 3 Li$_2$CO$_3$-Na$_2$CO$_3$-K$_2$CO$_3$ mixtures

- Freezing Temperature Range: 300 - 800°C
Experimental Break Points vs. Freezing Temperatures
Conclusions

- As long as smelt is completely molten, its viscosity varies between 2 and 5 cP, and is not affected by composition or temperature.

- Viscosity increases drastically as smelt begins to freeze.
Implication on "Jellyroll" Smelt Formation
Smelt Freezing Temperature

Temperature (°C)

Sulphidity (%)
Smelt First Freezing Temperature

Temperature (°C)

Sulphidity (%)
Jellyroll Smelt Prevention

- Increasing $\Delta T$ is the key

- Increasing $T_{Smelt}$
  - Increasing heat input to the boiler
  - Ensuring good combustion near spouts
  - Installing small hearth burners

- Lowering $T_{Freezing}$
  - Altering smelt composition of black liquor composition
  - Increasing sulphiidity
  - Increasing Cl, K and elemental S?
Other Contributing Factor: Char

- Highly porous
  - may act like “sponge” hindering smelt flow
- Much lighter than smelt
  - floats and may adrift like an iceberg
  - Block spout openings if sufficiently large
Outside surface of char block cools rapidly, resulting in smelt solidification.
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