Sintering and Structure Development in Alkali Metal Salt Deposits Formed in a Kraft Recovery Boiler

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Different Sized Particles that Plug Gas Passages in Recovery Boilers

Sub-micron condensation aerosols (fume)

Larger particles
Sintering and Hardening of Recovery Boiler Deposits

- Fume particles are sub-micron aerosols
- They begin to sinter at 300 to 350°C
- The rate of sintering increases rapidly with temperature

Techakijkajorn et al., 1999

Our Question

How do deposits sinter and harden in recovery boilers?
The Deposition Probe
Dust Collected at ESP Entrance

- Median diameter = 0.40 µm
- Mean diameter = 0.43 µm

Location of Probe Insertion Points
Deposit from Superheater (A)
Thermal load: 79%

Larger spherical particles at the surface of deposits from Superheater Location B

Thermal load: 79%
Thermal load: 122%
Cross-Sections of Deposits

Boiler Bank (C)
Load: 122%
Time: 30 min

Upstream sootblowers off

Upstream sootblower fired 1 min before probe was removed

Cross-Sections of Deposits

Load: 122%; Time: 15 min

Superheater (B)  
Boiler Bank (C)

Coarser structure

Finer structure
Sections of a Deposit from the Superheater (B)
Thermal load: 122%

Outer surface
(<1 minute)

Mid-plane
(5-10 minutes)

Structure of Deposits from Boiler Bank (C)
Thermal load: 122%, 10 min collection time
Structure of Deposits from Sinquefield/Sandia Study

Structure of Joutseno deposits are similar to Sandia probe deposits.

Mid-boiler bank (FMT = 536°C)

Sandia MFR probe sample, (FMT ~ 536°C)
The Sintering Mechanism
(Baxter, circa 1998)

Deposit Surface

Boiler Tube

Time

Analysis of Contacts

2-D: 2.2±1.0
3-D: 2.6±1.4
Sintering depends upon the coordination number, $N_c$…

- $N_c$ = number of contact points between particles
- Initially, $N_c$ depends upon
  - Structure
  - Packing density
  - Polydispersity
- $N_c$ usually changes during sintering
- Initial $N_c$ must be
  - >2 to generate chains
  - At least 4 to develop system rigidity

Sintering rate depends upon first melting temperature
(Frederick, Lien, Tran, 2000)
First melting temperature increases with deposition time

![Graph showing first melting temperature increases with deposition time.](image)

Carbonate content decreases with deposition time

![Graph showing carbonate content decreases with deposition time.](image)
Conclusions

• Fume deposits form with a very open structure
• Grains grow as they sinter, but with little early densification of the deposit

Conclusions

• Larger, intermediate size particles probably fuse together via
  – sintering of the dendritic, submicron fume particles that deposit on their surfaces, and
  – sintering of the agglomerates of the finer particles in contact with them.
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