PEERS
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ATLANTA, GEORGIA
Sustainable Solutions for our Future
TAPPI 100 YEARS
A CENTURY OF ACHIEVEMENT

Chemical Additives to Optimize Black Liquor Recovery Throughput and Increase Campaign Life

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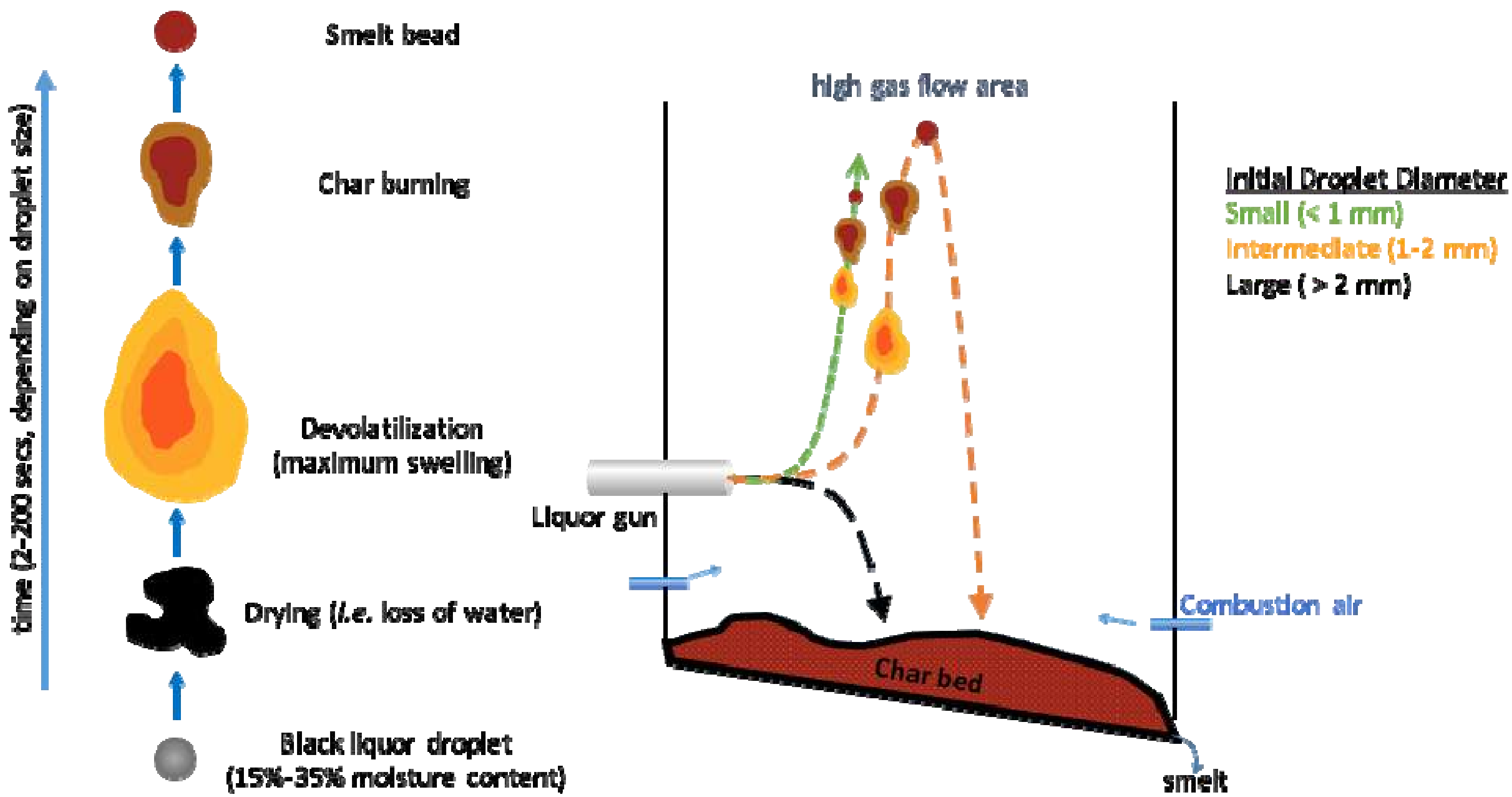
FUEL TECH®
Technologies to enable clean efficient energy

Agenda

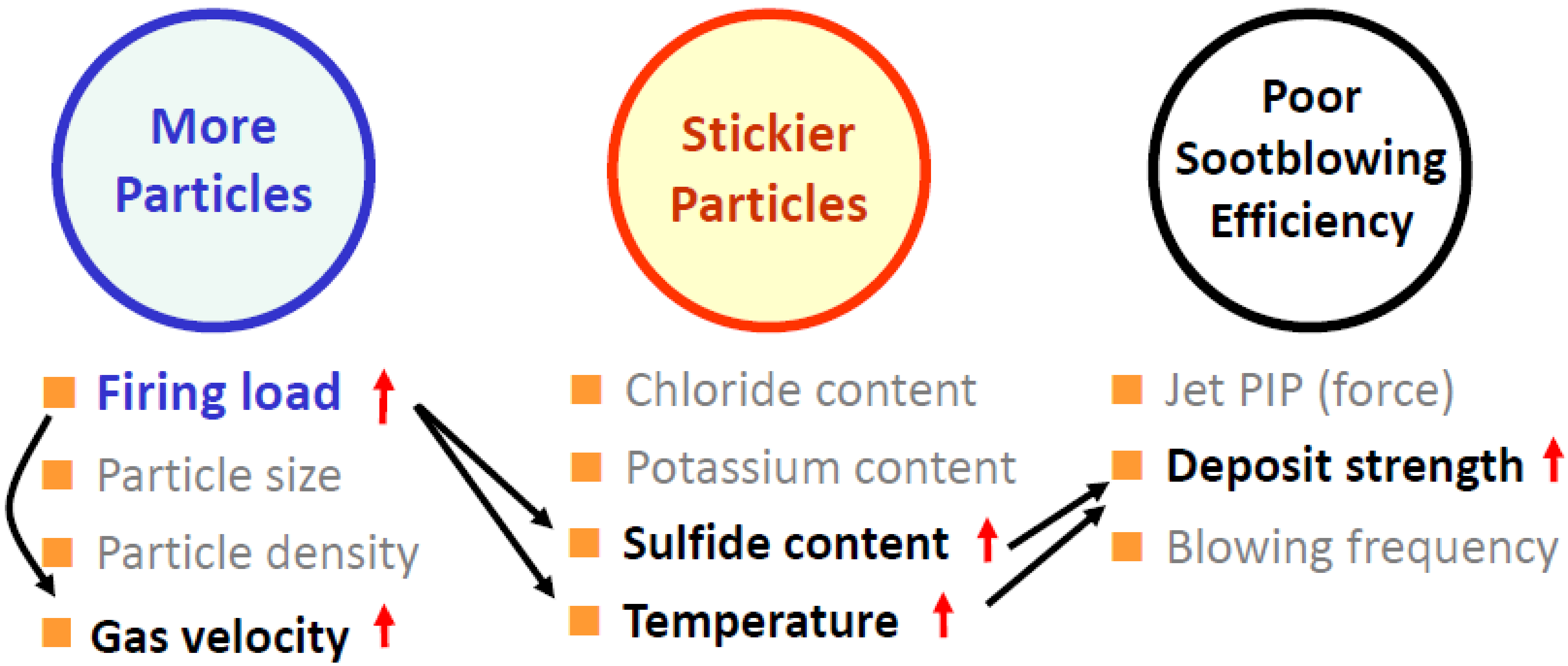
- Deposit formation in black liquor recovery boilers
  - Fate of black liquor droplets
  - Composition of carryover and deposits
  - Deposition mechanism
- Chemical additives
  - What are they?
  - Targeted application
  - Operation mechanism
- Case study
  - Twenty years of continuous operation
    - Supporting mechanical upgrades with chemical additives

Fate of Black Liquor Droplets



References: (a) Hupa, M., Solin, P., Hyöty, P., "Combustion behavior of black liquor droplets," *J. Pulp Paper Sci*., 13(2):J67-72 (1987). (b) Frederick, W.J., Hupa, M., "Optical pyrometric measurements of surface temperatures during black liquor char burning and gasification," *Fuel*, 73(12):1889-1894 (1994).

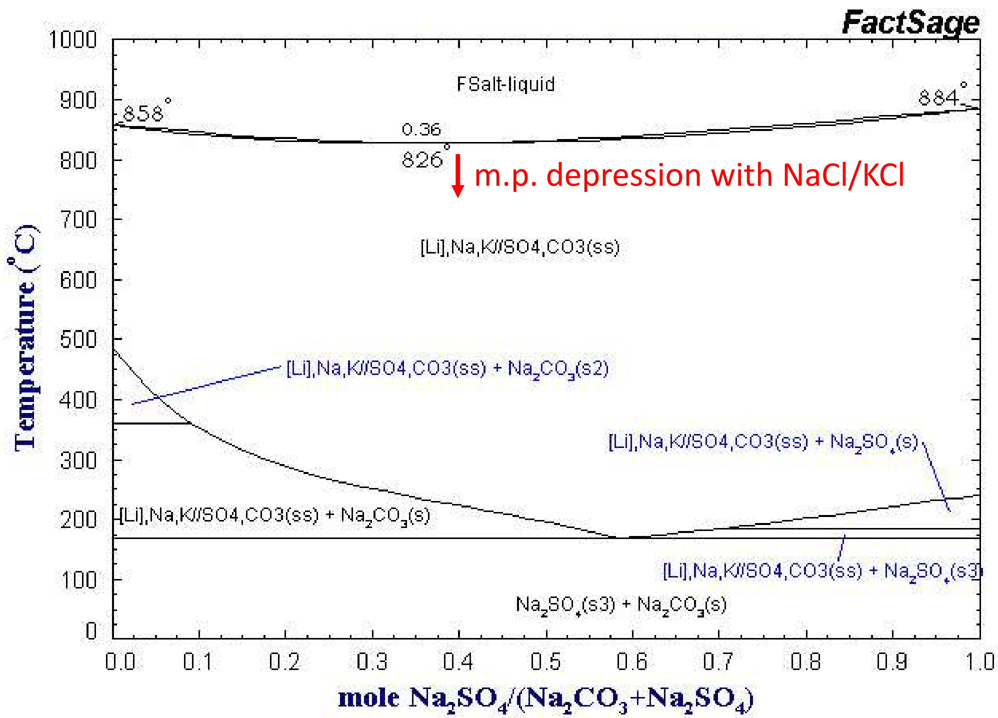
Recovery Boiler Fouling Causes

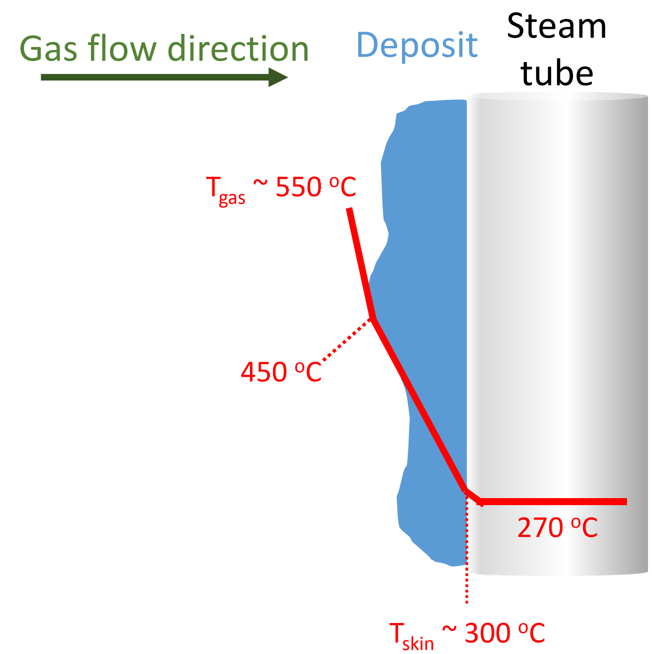


Load is the most important variable affecting fouling!

Reference: Tran, H. 2015 TAPPI Kraft Black Liquor Recovery Course Lecture Notes

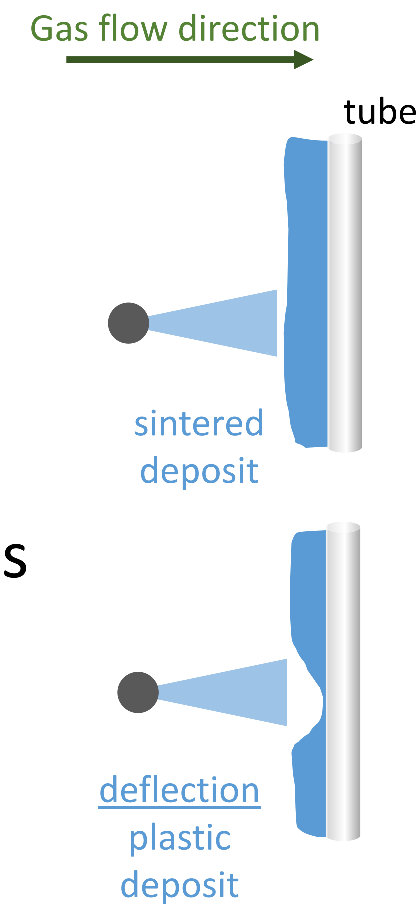
Melting Characteristics of Deposits





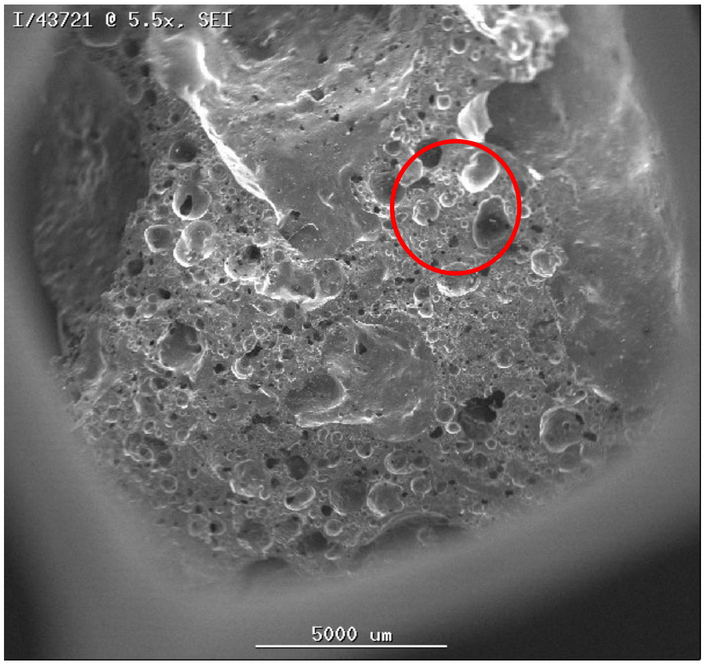
- Melting temperature between 825 °C (1517 °F) and 885 °C (1625 °F)
  - NaCl and KCl depress the melting point (*e.g.* fluxing agent) to 626 °C (1159 °F), plasticizing agents
- Partially molten (*i.e.* "sticky") inorganic salts condense on cooler heat transfer surfaces
  - As deposit grows, leading edge approaches surrounding gas temperature
  - Leading edge can be "sticky," adhering additional particles and carryover
- Deposits sinter into dense masses at $T > 450$ °C

Deposit Removal

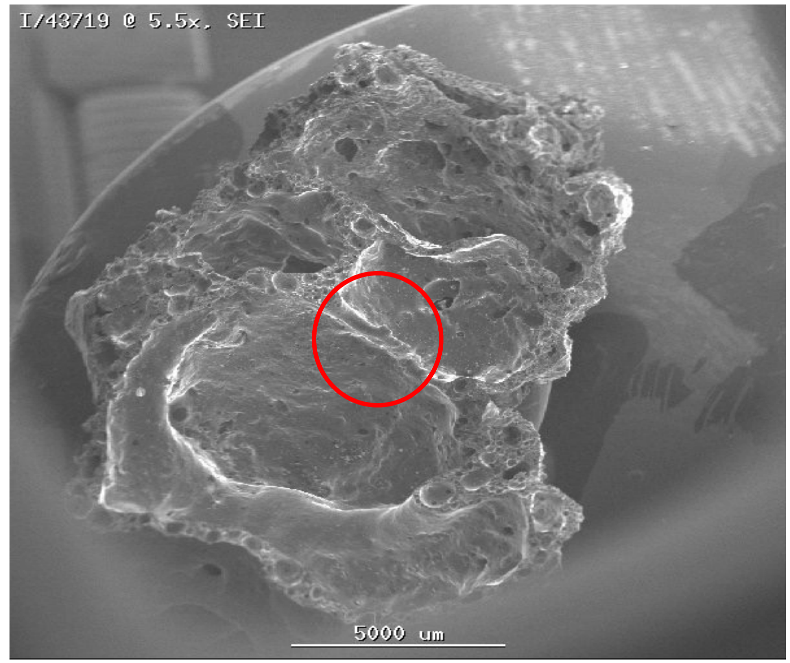


- Motive force is critical to deposit removal
  - Sootblowers, sonic horns, impulse cleaners, etc.
- Sootblowers are often ineffective when:
  - Deposits sinter into dense masses
  - Deposits are above their fluid or plastic temperatures
- Chemical additives alter deposit physical characteristics
  - Microscopic: pore structure, local melting temperature
  - Macroscopic: pore structure, compression strength

Modification of Deposit Physical Properties



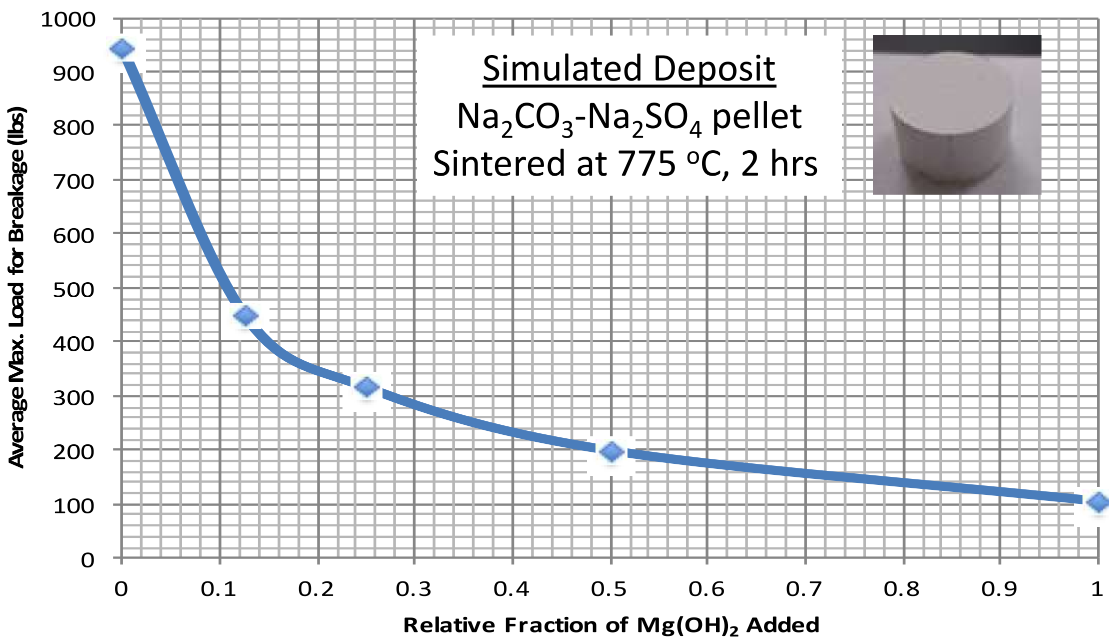
Numerous small pores with thick pore walls



Large pores with thinner pore walls

- Addition of $Mg(OH)_2$ modifies deposit pore structure
  - Untreated deposits contain numerous small pores with thick walls
  - Treated deposits contain larger pores with thinner walls in between adjacent pores

Modification of Deposit Physical Properties

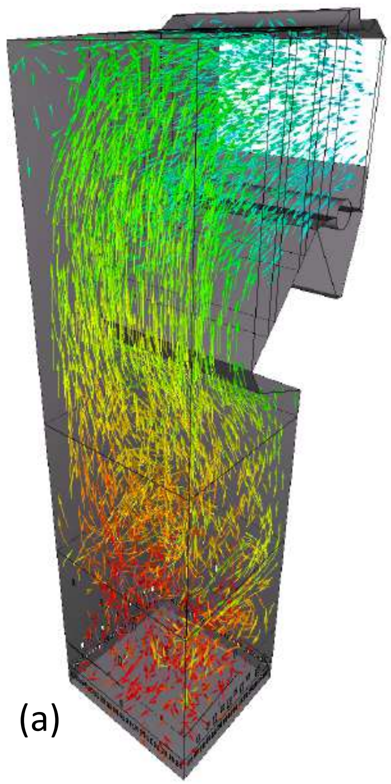


- Microscopic-scale phenomena impact bulk properties
  - Force required to break sintered pellet decreases with increasing additive dose

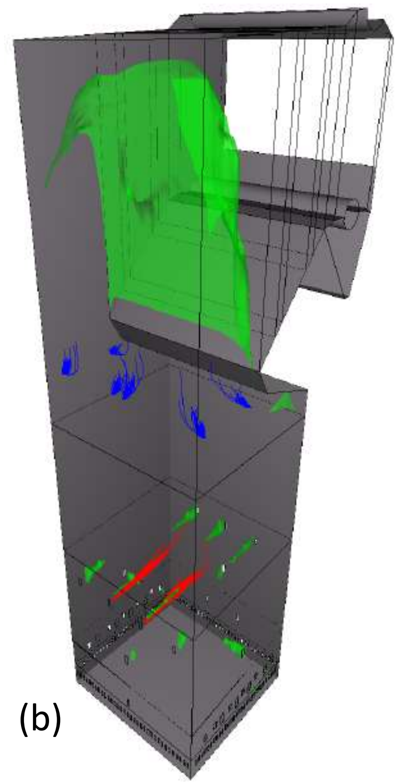
Targeted Application

Targeted Program Application

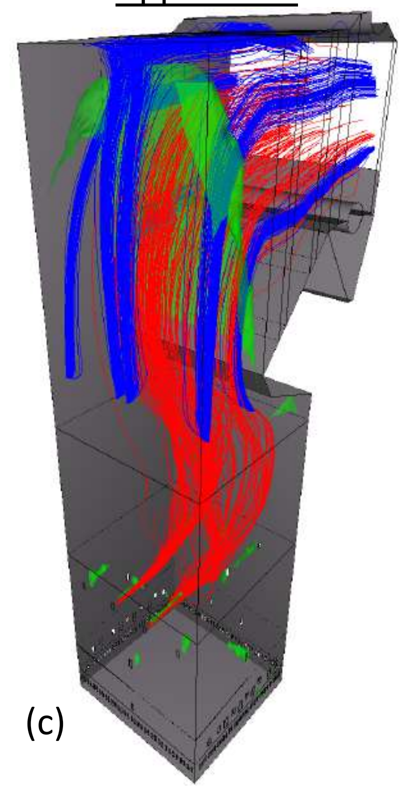
Gas Flow Dynamics



Prediction of Problem Areas



Targeted $Mg(OH)_2$ Application

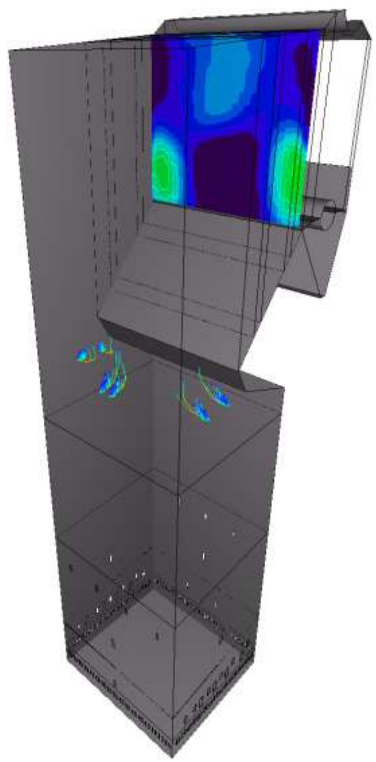


Chemical Coverage in Problem Areas

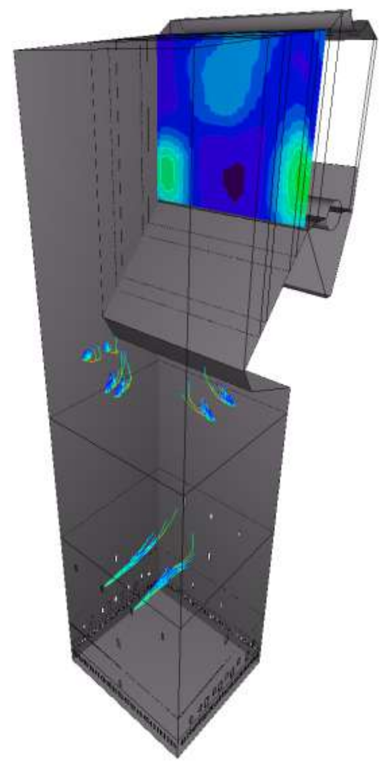
Coverage Entering Generating Bank – Dosage: 0.9 lb/ton

Fuel Case: Softwood

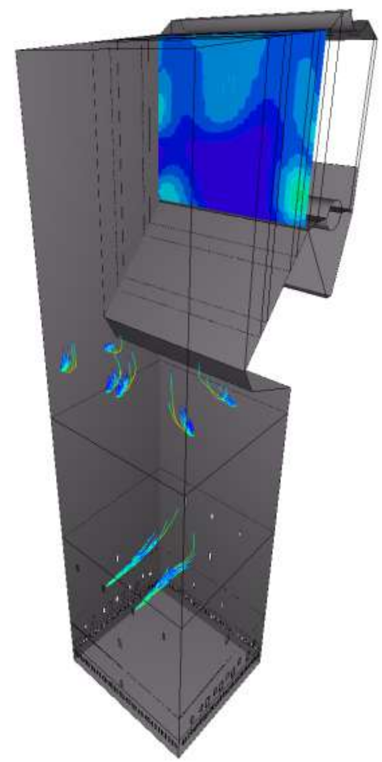
Solids Firing: 4.1MMlb/D



6 injector array



8 injector array



Optimized array

RECOVERY-CHEM® Recovery Boiler Technology

Program Application:

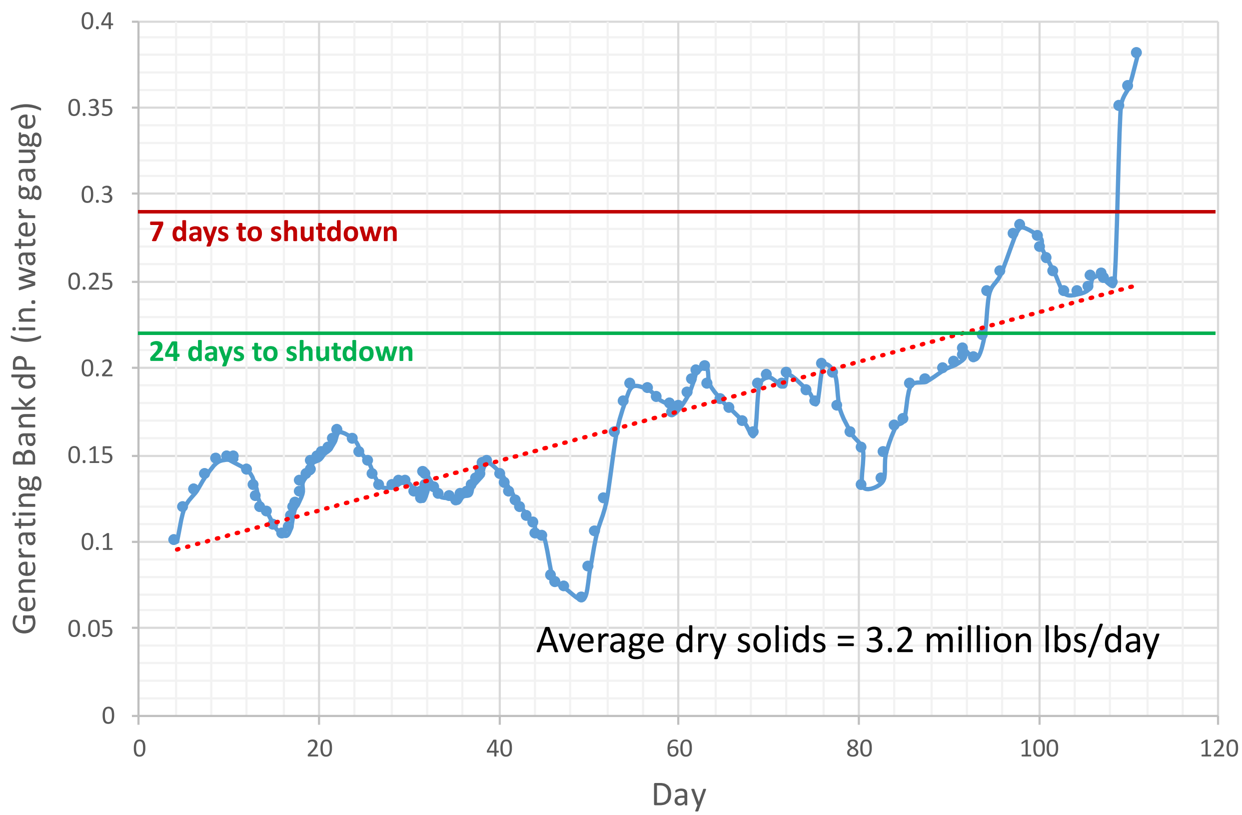
- The chemical program is injected into the fireside of the boiler at specific locations based on Fuel Tech's CFD model of the boiler.

Chemical Injection Technology

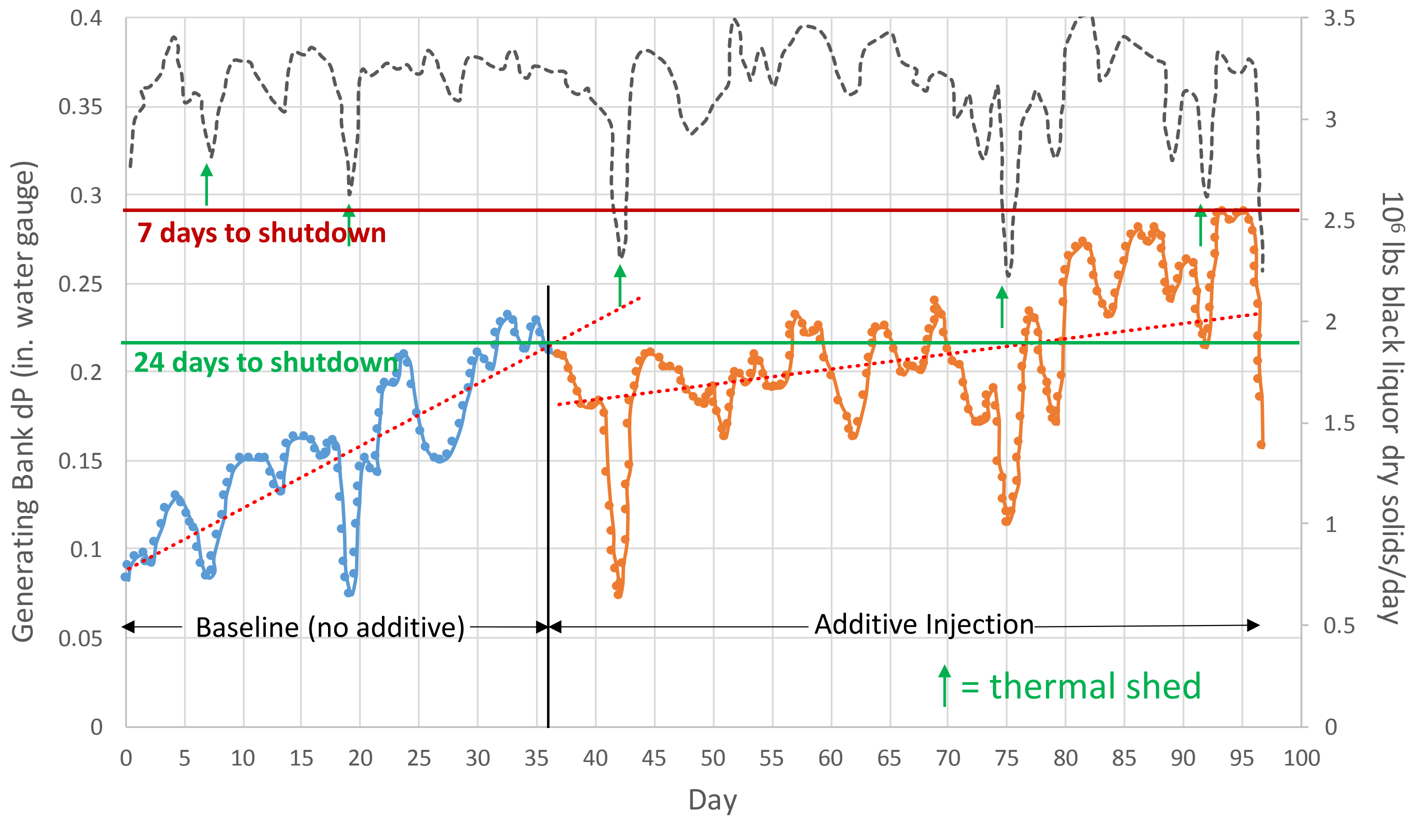
- Tunable droplet size characteristics
  - Fine mist for rapid evaporation and activation of $Mg(OH)_2$ particles

Case Study

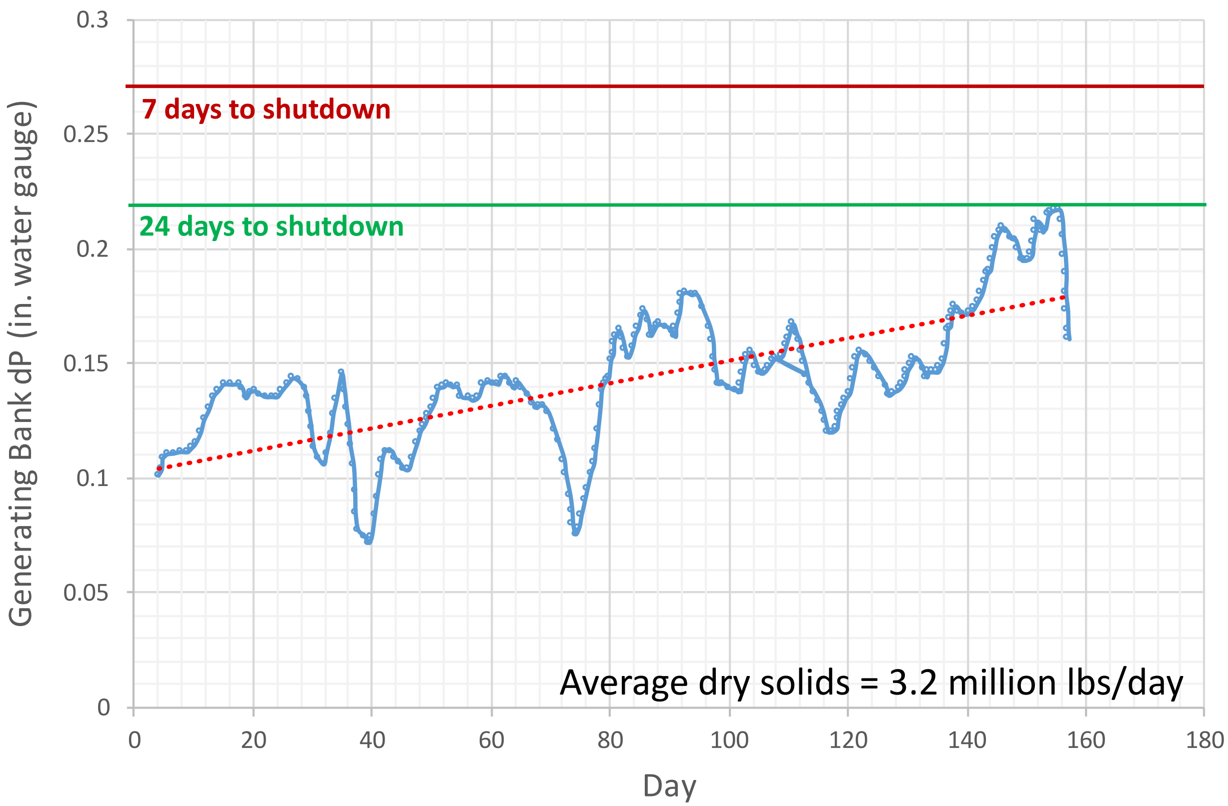
Baseline Data (1995) – Without RECOVERY-CHEM



Treatment Extends Campaign Life

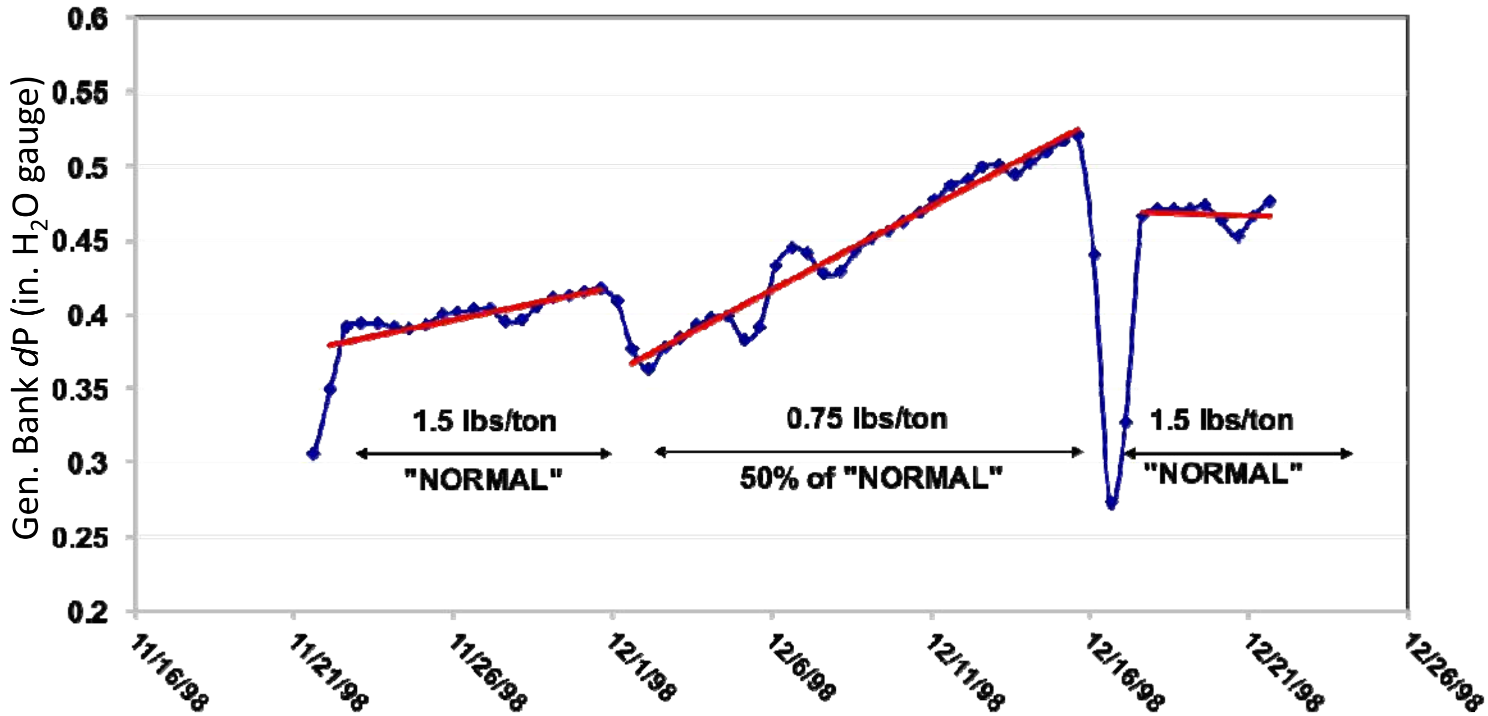


Run 3

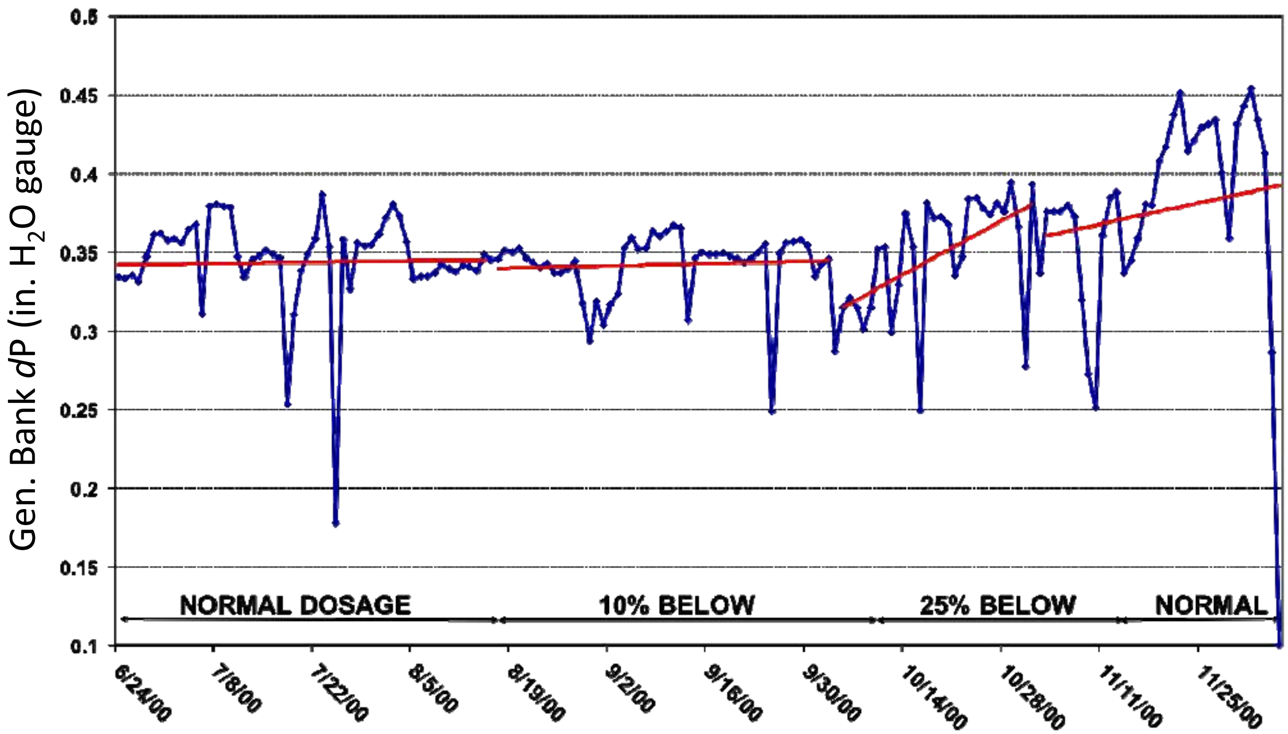


0.3
0.25
0.2
0.15
0.1
0.05
0
7 days to shutdown
24 days to shutdown
Generating Bank dP (in. water gauge)
Average dry solids = 3.2 million lbs/day
0
20
40
60
80
100
120
140
160
180
Day

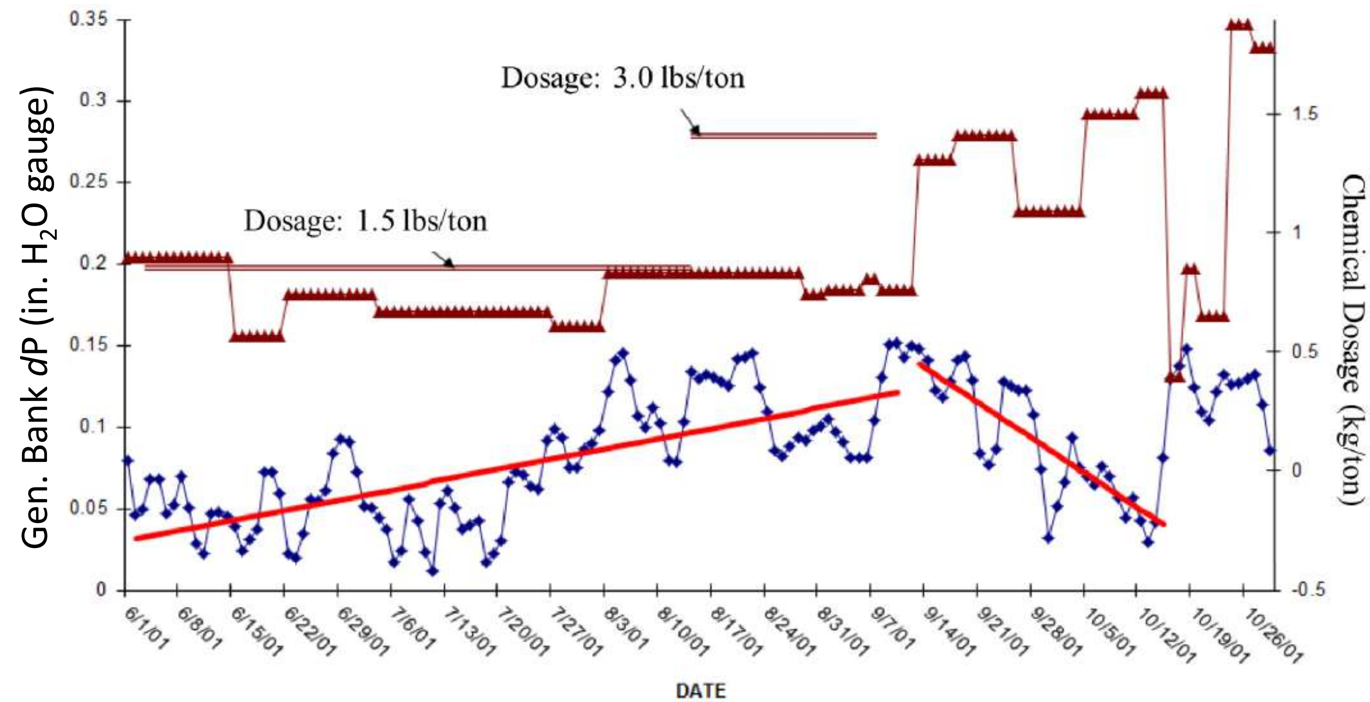
Dosage Optimization Trials : Fine Tuning



Dosage Optimization Trials : Fine Tuning

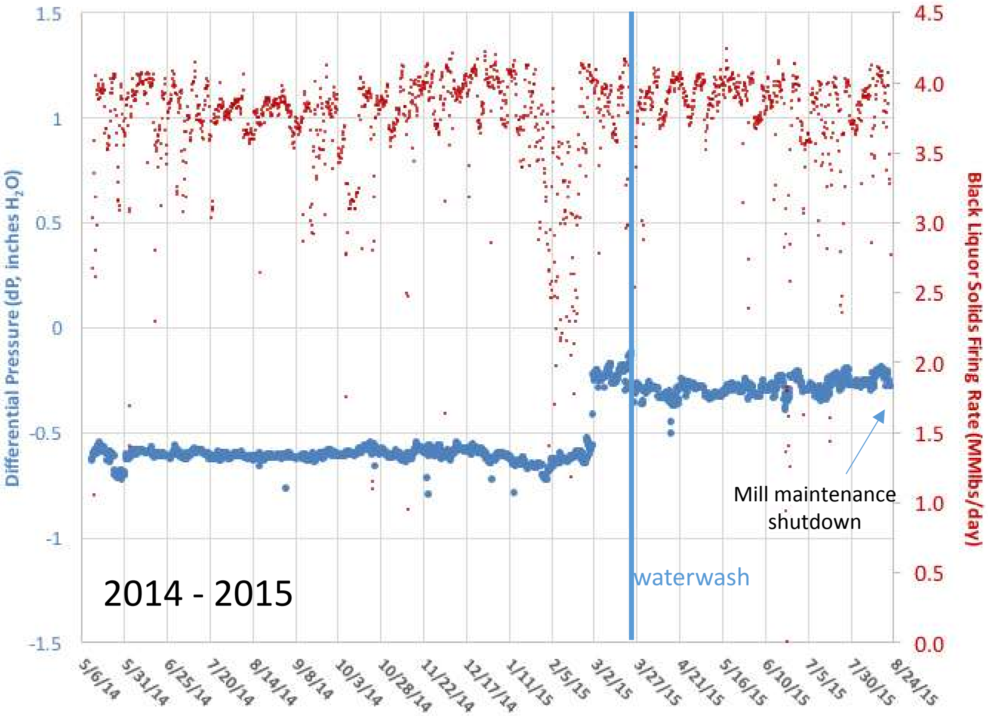


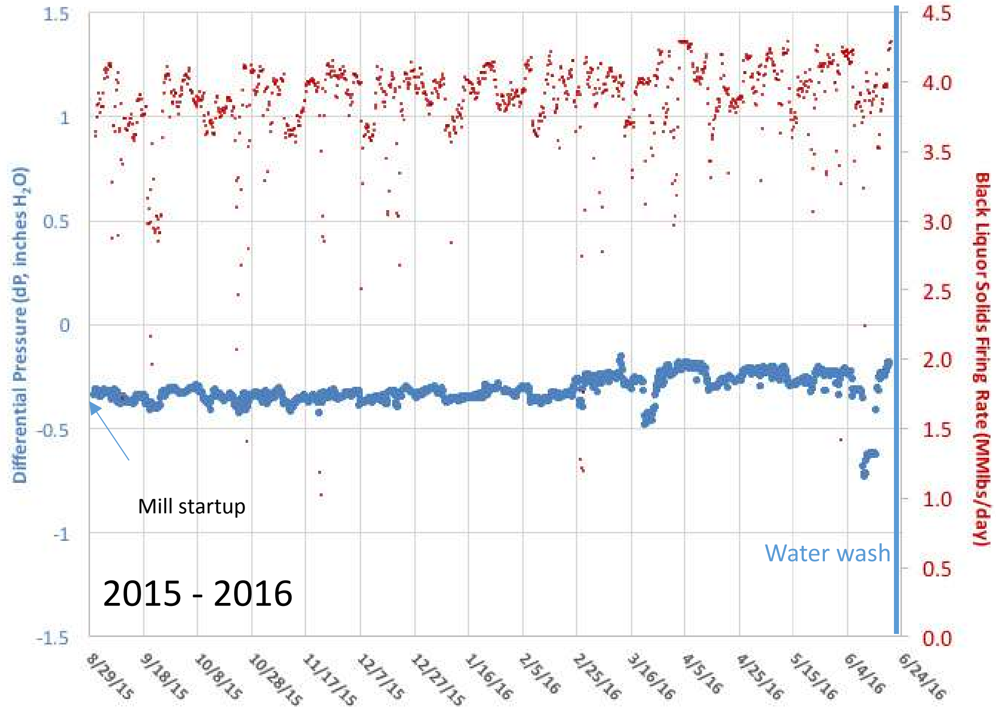
Dosage Optimization Trials : Reversal



- dP increase can be reversed with increased chemical injection

Increased Campaign Life





- 11 month run completed with 4.07 MM lbs/day of BL dry solids firing

Summary

- Sodium salts in the recovery unit deposit on heat transfer surfaces and sinter at $T > 450\ ^{o}C$ ($842\ ^{o}F$)
- Sootblowers lose efficiency as deposits continue to grow and sinter
- $Mg(OH)_2$ injection reduces deposit strength
  - Sootblowers are more effective
- Mechanical upgrades to increase throughput greatly benefit from deposit control programs
  - Mechanical upgrades increase throughput
  - Chemical additives maintain a clean boiler to sustain increased throughput
- Twenty years of operating experience
  - Have increased campaign life from 60 days to 330 days
  - Decreased "chill and blow" frequency by 50%-75%

Thank you!

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