FLY ASH EROSION
CONTROL & PREVENTION

RECENT DEVELOPMENTS

JOHN DRENNEN, PE
DRENNEN ENGINEERING, INC.
FLY ASH EROSION (FAE)

LEADING CAUSE OF BTF

PREVENTABLE…
IN MOST CASES

OLD TECHNOLOGY…
& NEW TOOLS
FACTORS CONTRIBUTING TO INCREASED FAE

- GAPS, OPENINGS
- TURNS IN FLOW PATH
- SOOTBLOWING
- FUEL CHANGE
- HIGHER LOAD
- PP CHANGES
- FUEL FIRING EQUIP
- ASH PLUGGING
- EROSION CONTROLS

- LOWER FLOW RESISTANCE
- CENTRIFUGAL SEPARATION
- FLY ASH SURGES
- MORE ASH
- HIGHER FLOW
- PREFERENTIAL FLOW
- TIME-TEMP HISTORY
- DECREASE FLOW AREA
- CAN MOVE PROBLEM
FAE EQUATION

- \( E = C \times M \times V^n \times C_p \)
- \( E \) – Erosion Rate
- \( C \) – Correlation Const.
- \( M \) – Mass Flux
- \( V \) – Gas Velocity
- \( n \) – exponent (2.5 - 3.5)
- \( C_p \) – Particle Size Adjustment
Relative Erosion Rates

\[ \frac{E_1}{E_{avg}} = \left( \frac{M_1}{M_a} \right) \times \left( \frac{V_1}{V_a} \right)^n \times \left( \frac{C_{p1}}{C_{pa}} \right) \]

Relative Erosion Rates

(E1/Eavg, n=2.4)
LARGE BOILER
>750 MW

FAE AREAS:
PERIMETER
IN-BANK

APPROACH:
CAVT
COMPUTER MODEL
MID-SIZE BOILER
200 - 750 MW

FAE AREAS:
REAR PASS NEAR REAR WALL

APPROACH:
COMPUTER & PHYSICAL MODEL FOLLOW-UP CAVT
SMALL BOILER < 200 MW

FAE AREA: ECON NEAR REAR WALL

APPROACH: COMPUTER MODEL
APPROACH TO FAE REDUCTION

- IDENTIFY ROOT CAUSE
  GAS & ASH DISTRIBUTION, OTHER…
- MEASURE / MODEL DISTRIBUTIONS
  CAVT, COMPUTER, PHYSICAL MODEL
- REDISTRIBUTUE FLOWS
  FLOW MODIFICATION BAFFLES
COLD AIR VELOCITY TEST

- Measure Gas Flow Distribution
  - FULL SCALE PHYSICAL MODEL
- Testing in Unit w/ Fans Running
- Multiple Teams
- Flow Visualization
COLD AIR VELOCITY TEST
- Multiple Teams at Different Planes
- One Person Measures, the Other Records Readings & Notes
- Safety Person for Each Team Outside at Same Plane
- Control Room Operator Sets and Monitors Flow and Other Equipment to Support Test.
FLOW VISUALIZATION
FLOW VISUALIZATION
COMPUTER MODELING

- 2-D OR 3-D
  - DEPENDS ON SYMMETRY
- AMBIENT TEMPERATURE (CAVT)
- OPERATING CONDITIONS
  - W/ HEAT EXTRACTION
- GROSS FLOW DISTRIBUTION
  - GAS AND PARTICULATE
- ESTIMATE RELATIVE FAE RATE
- DETAILED AREA MODELS
2-1/2-D CFD Model Geometry

Nominal 1 Ft Wide Slice Model

Inlet
Div Wall
Outlet

HTSH
3-D MODEL

PA DUCT EXTRACTION
ASSYMMETRIC
TEMPERATURE

INLET – 2350°F

OUTLET – 700°F
PARTICULATE
30 & 53 MICRON
PARTICULATE
74, 88, 105
MICRON
PARTICULATE

177, 210
MICRON
Relative Mass Loading w/ Size Correction
Rear Pass at Operating Conditions

40% REDUCTION

Uniform ash / size distribution = 1.0
MID-SIZE BOILER
200 - 750 MW

FAE AREAS:
REAR PASS NEAR REAR WALL

APPROACH:
COMPUTER & PHYSICAL MODEL FOLLOW-UP CAVT
2-1/2-D CFD Model Geometry

- Hanger Tubes
- Screen Tubes
- Nominal 1 Ft Wide Slice Model
- HTSH
- LTSH
- Inlet
- Div Wall
- Outlet

400 MW
CFD Model Geometry

MAIN DIAGONAL SCREEN & TUBE BEND BAFFLES

LADDER VANE BAFFLE

FLOW
10 23 100 $\mu$ Particle Tracks

EMS BAFFLE
Relative Erosion at Upper Rear LTSH Inlet

NEW FAE Controls

- **Mass Wtd.**
- **Mass & Part.**

**Peak in Front Sect Due to Jet off Vanes**

**No Major Particle Shift to Rear**

**Rear Sect. Below Avg.**

- Relative Erosion at Upper Rear LTSH Inlet
- Peak in Front Sect Due to Jet off Vanes
- No Major Particle Shift to Rear
- Rear Sect. Below Avg.
SMALL BOILER < 200 MW

FAE AREA: ECON NEAR REAR WALL

APPROACH: COMPUTER MODEL
FLOW VISUALIZATION
Trajectories for 10 Micron Ash Particles

Economizer Inlet Plane

Normalized Erosion Rate

Economizer Tube Row Number
Trajectories for 10 Micron Ash Particles

Economizer Inlet Plane
OTHER ISSUES

- IN BANK FAE
- TUBE ALIGNMENT
- PLUGGING
- TEMPERATURE
Particle Tracks Through Bank

Particles are deflected off of top row and then again by 4th row into Rows 5-8, where the most serious FAE occurs.

Particle Sizes Shown ($\mu$) : 44, 62, 88, 125, 177, 250, 420
Particles are deflected by top row and 4th row tubes into Row’s 5 - 8, where most serious FAE occurs.
Particle Tracks at Top of Bank

Particle Sizes Shown (μ):
44, 62, 88, 125, 177, 250, 420
FLOW TO SIDEWALL GAP & TUBE ALIGNMENT
PLUGGING DUE TO SOOTBLOWING
PLUGGING DUE TO CARRYOVER
ASH DEFLECTION SCREENS
SUMMARY

STEPS TO REDUCE FAE

- IDENTIFY LOCATIONS – FAE – ROOT CAUSE
- GET FLOW DISTRIBUTIONS
  GAS AND FLY ASH
  CAVT, COMPUTER OR PHYSICAL MODEL
- CORRELATE FAE TO FLOW DISTRIBUTIONS
- SELECT BAFFLES TO REDISTRIBUTE FLOW
- GET MODIFIED DISTRIBUTIONS W/ BAFFLES
- CAUTIONARY ITEMS
  PLUGGING, TEMPERATURE