Reinhold Environmental Ltd.

2010 NOx-Combustion Round Table & Expo Presentation

February 8 & 9, 2010 Chattanooga, TN

Boiler Control Challenges Discussion Group

Primary Air & Secondary Air Measurement

Robert Mudry, P.E.

Airflow Sciences Corporation
Livonia, Michigan
734-525-0300

NOx-Combustion Round Table
February 9, 2010

PA & SA Measurement

- Why measure?
  - Need to control boiler flow rates properly for safe, efficient operation with minimized emissions
    - Save $ for every pound of fuel saved
    - Save $ for every pound of emissions reduction
    - Save $ for reduced maintenance expenses
- Measurements
  - Mass flow (kpph) = density (lb/ft^3) * flow volume (ACFM)
    - Total air flow
    - Temperature
    - Pressure
  - PA & SA are key for boiler control
  - Flow split (compartments, OFA, per mill) are important
  - Other flows may be of interest (seal air, inleakage, moisture, …)

PA & SA Measurement

- Methods
  - Orifice
  - Venturi
  - Airfoils

  } Create flow blockage; measure DP across it; flow rate is proportional to $\sqrt{DP}$

  - Pitot
  - Hot wire
  - Microwave
  - Other

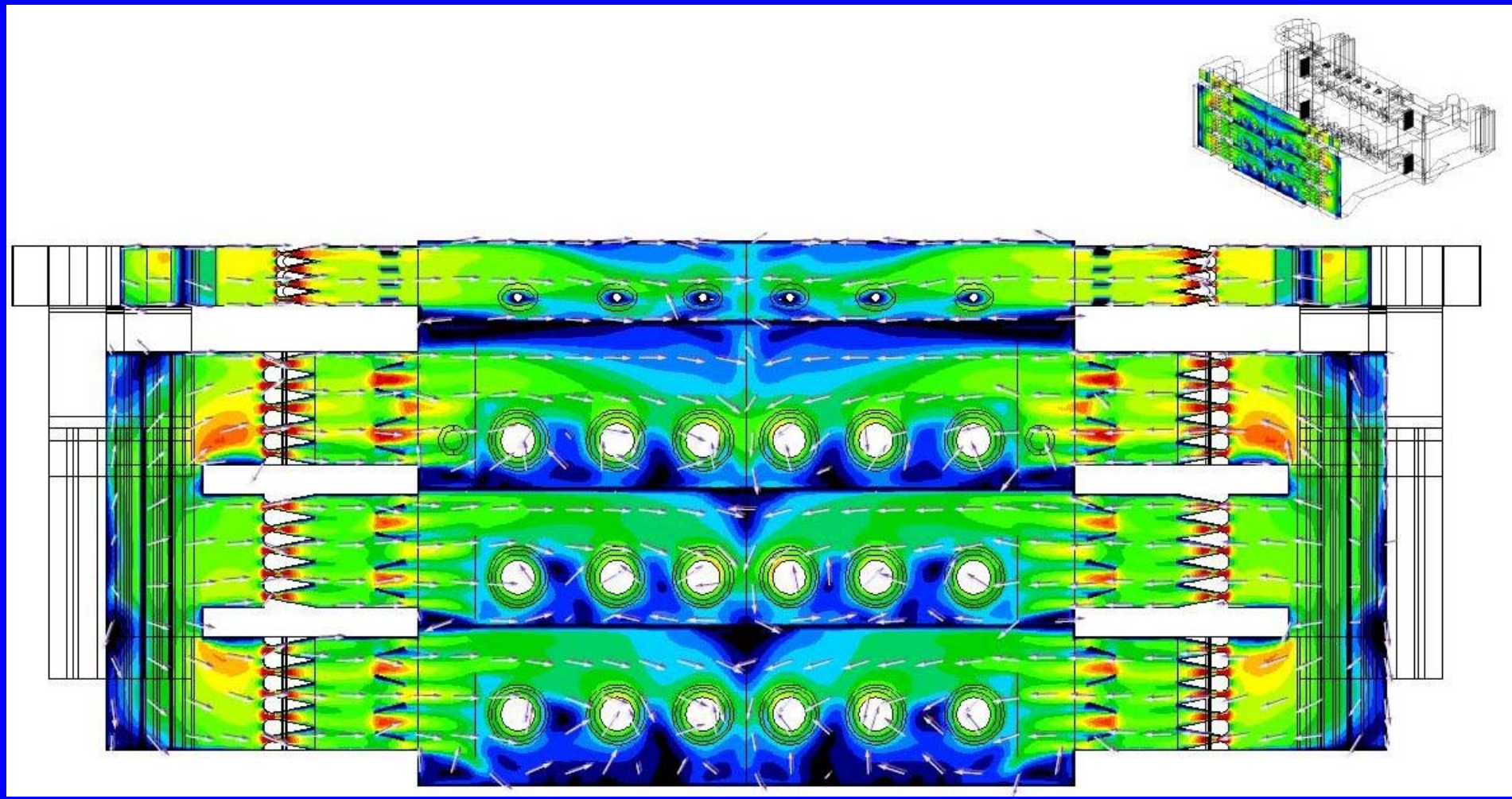
  } Instrumentation measures flow velocity and temperature; often multiple probes per duct; calculates flow rate based on duct area; output is fed into control system

PA & SA Measurement

- Venturi
  - Allows pressure recovery compared to orifice

PA & SA Measurement

- Airfoils



PA & SA Measurement

- Methods
  - Orifice
  - Venturi

    } Single measurement per duct
  - Airfoils
  - Pitot

    } Usually multiple measurement points to obtain duct average; pressures may be tee-d together
  - Hot wire
  - Microwave

    } May use multiple measurement points to obtain duct average
  - Other

PA & SA Measurement

- Calibration
  - System calibration via duct traverse
    - Need good test ports
    - EPA Method 2, 2F
    - S-probe or 3D probe

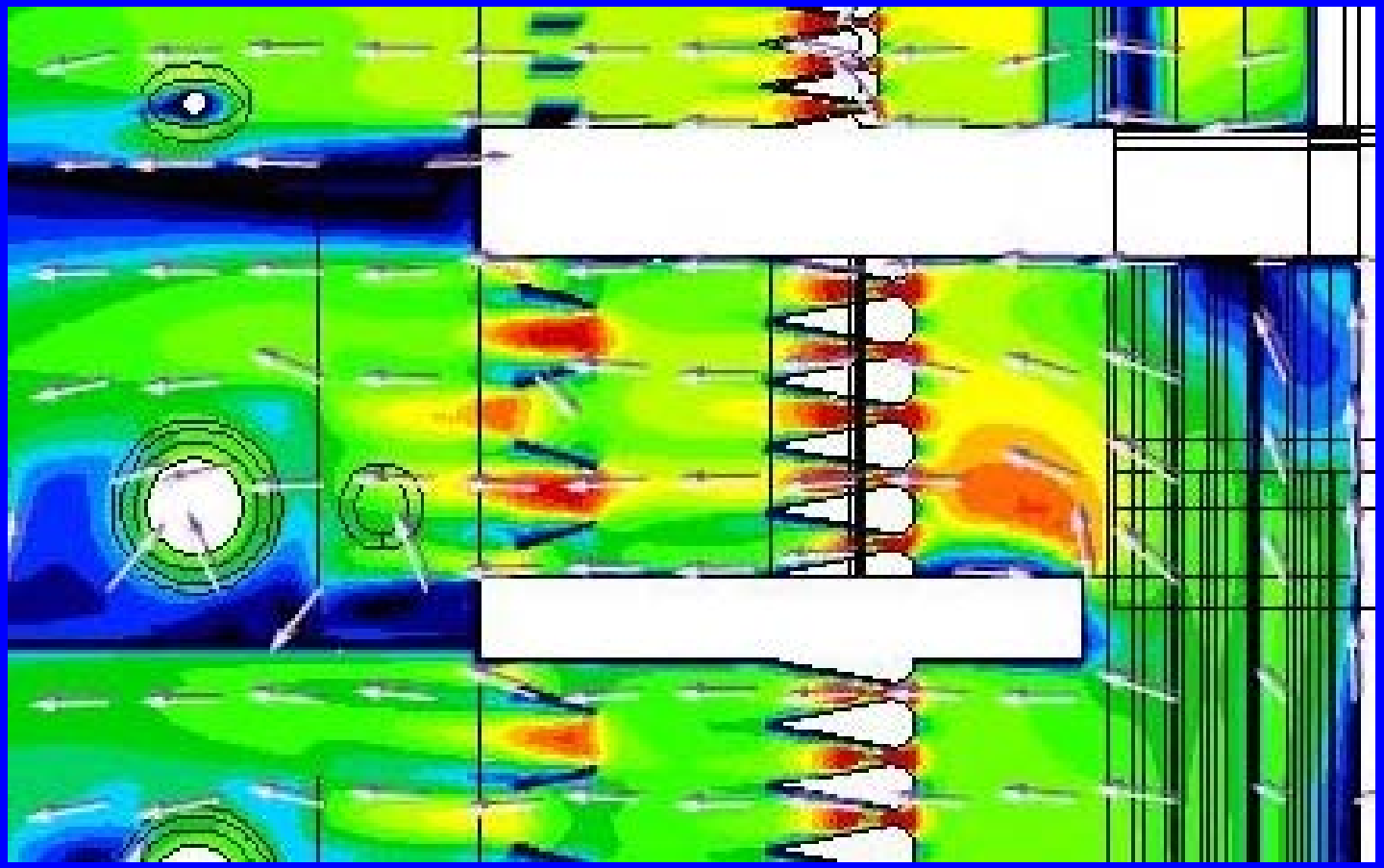
  - Component calibration
    - By vendor
    - By user
- Calibration frequency
  - System – annually
  - Component – varies by vendor

PA & SA Measurement

- Challenges
  - High pressure (+40 inches of water)
  - Hot (650-750 F)
  - Particulate
    - Erosion
    - Pluggage
    - Fouling
  - Dampers
  - Limited space
  - Velocity patterns
  - Temperature gradients

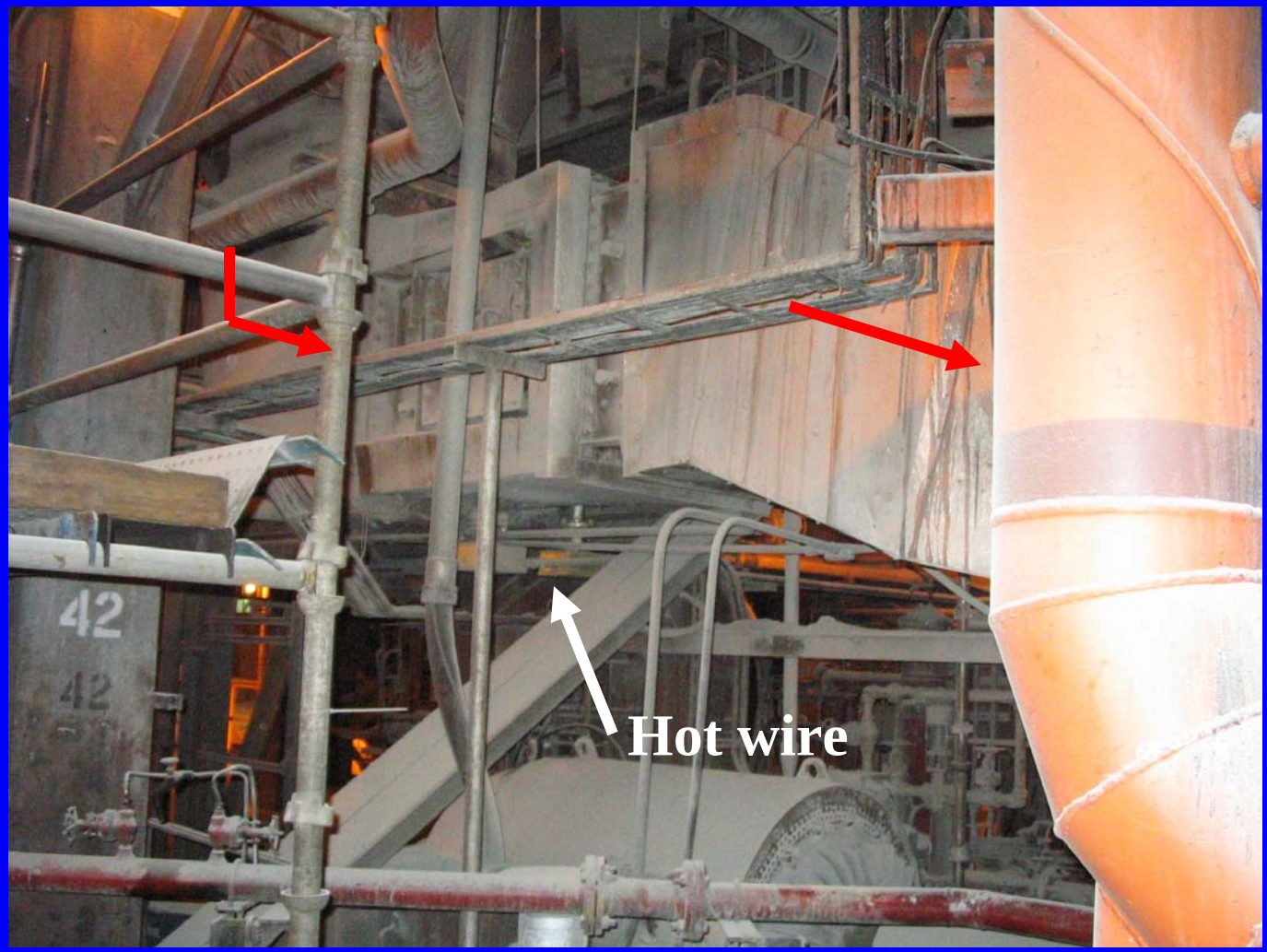
PA & SA Measurement

- Limited space for test ports and calibration – Airfoils



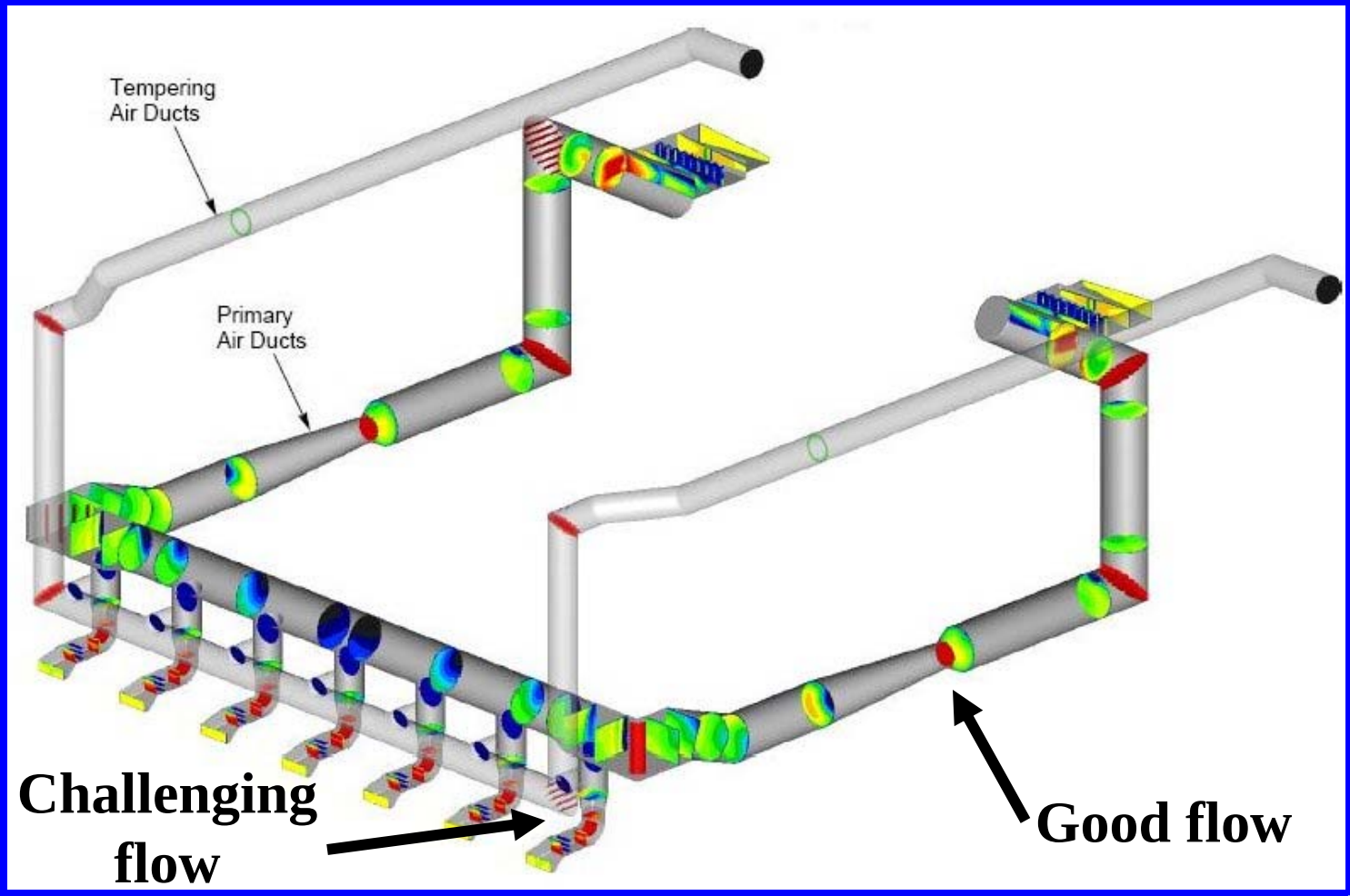
PA & SA Measurement

- Limited space for hot wire install – mill inlet



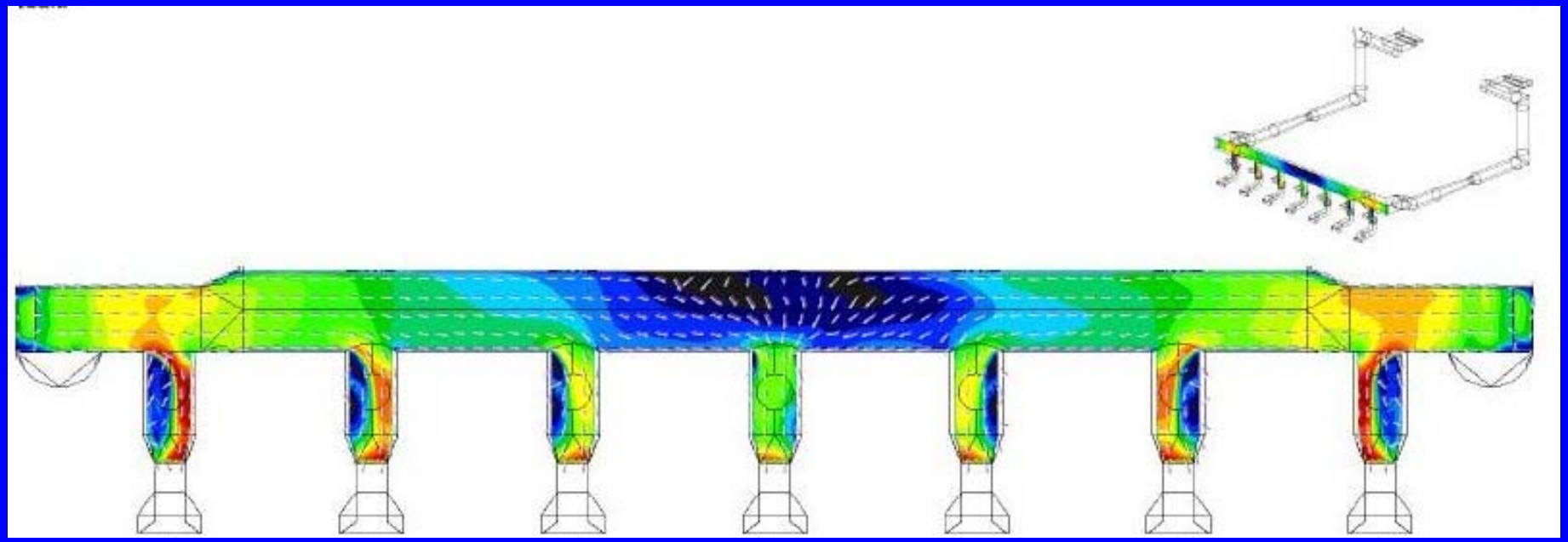
PA & SA Measurement

- Velocity Patterns



PA & SA Measurement

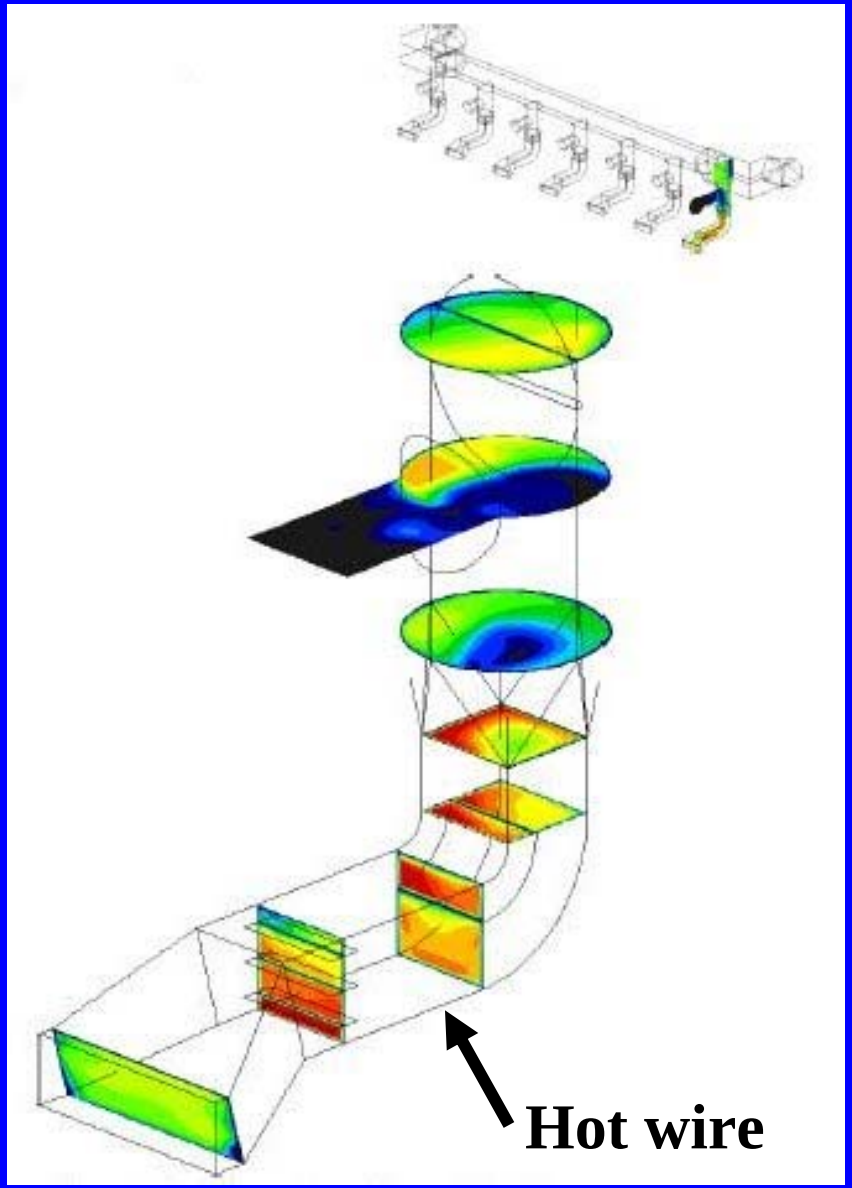
- Velocity Patterns



Outboard mills have most skewed velocity

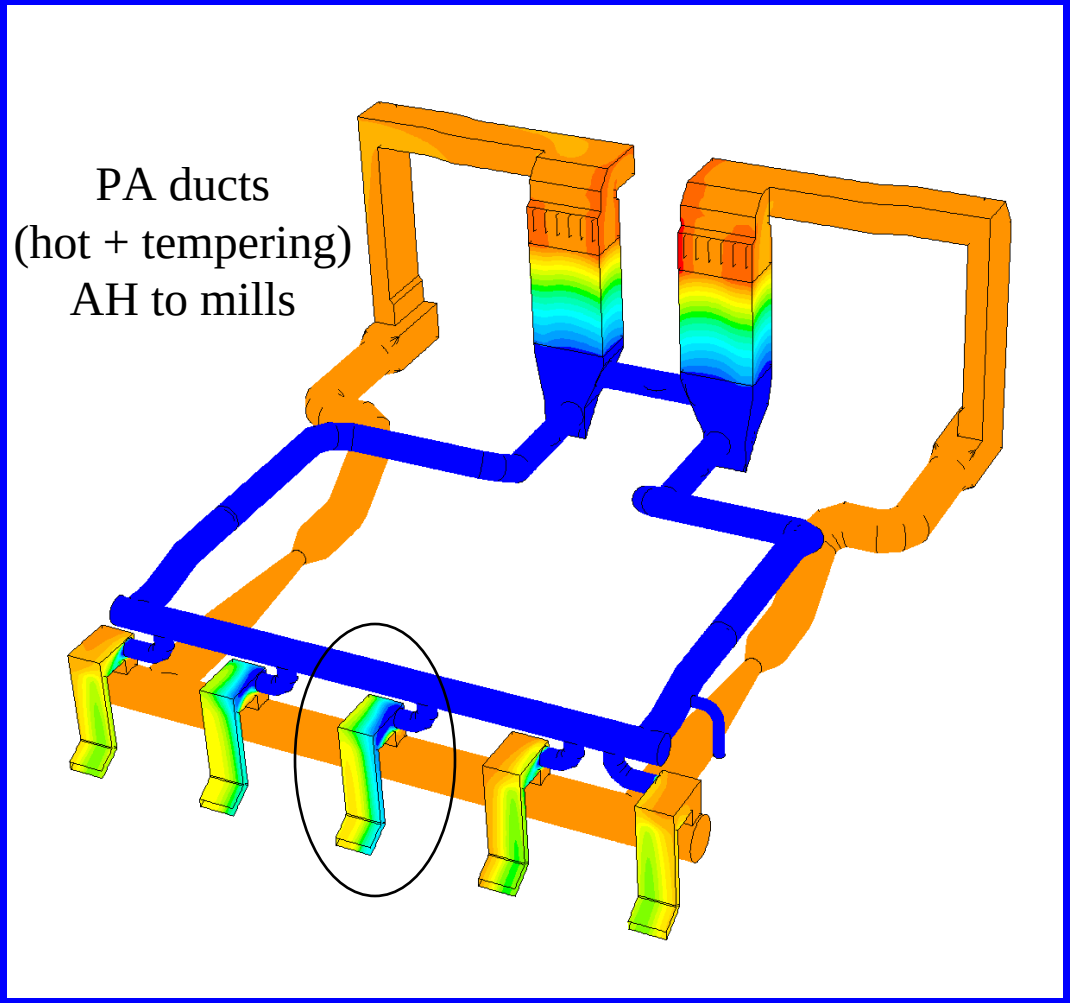
PA & SA Measurement

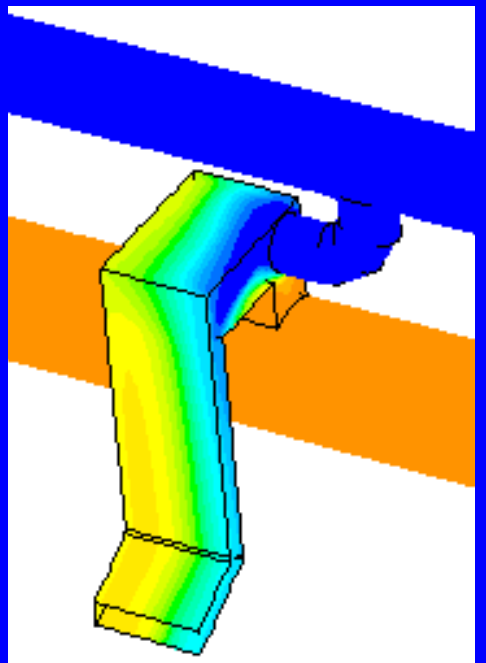
- Velocity Patterns
  - Flow uniformity
  - Directionality



PA & SA Measurement

- Temperature gradients – impact flow density





Close-up, Mill C
ΔT = 80 F

PA & SA Measurement

- All good methods, but have design considerations
  - Orifice
  - Venturi
  - Airfoils

  } Add to system DP; susceptible to pluggage, transducer drift, velocity profile

  - Pitot
  - Hot wire
  - Microwave
  - Other

  } Susceptible to pluggage, fouling, erosion, drift velocity profile and directionality; can be removed for repairs and calibration

Summary

- Many options for PA and SA measurement
- All can work well, if properly installed
  - Good flow distribution and directionality can be critical
  - Uniform temperature important
  - Purging systems to avoid pluggage
- And if properly maintained
  - Inspection for erosion, fouling
  - Regular and accurate calibration of system and components
    - Need good test ports
    - Did I mention you need good test ports?
    - 3D probe better than S probe