Computational Modeling –
B&W Applications in Black Liquor
Combustion and Gasification

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B&W’s Combustion Model, COMO℠
• COMO is a proprietary CFD and combustion code
• Engineering group is dedicated to model development and applications for B&W products in Barberton, Ohio, USA
• B&W history of CFD model development since 1975
• Commercial CFD codes and analysis tools also used when applicable
• Scope of technology:
  - Processes
    - Flow
    - Heat transfer
    - Combustion
    - Pollution
    - Deposition
    - Erosion
  - Fuels
    - Coal
    - Oil
    - Gas
    - Wood
    - Refuse
    - Black liquor
  - Products
    - Boilers
    - Burners
    - Gasifiers
    - Wet scrubbers
    - Steam generators
    - SCR
**Geometric Flexibility of Unstructured Mesh**

Primary Air-Port with Casting

Recovery Boiler Air Systems

**Application - Recovery Boiler Upgrade**

- Air System Design
- Liquor Distribution
- Capacity Increase
- Carryover, ISP, and Fume
- CO and NOx
- Furnace heat flux and circulation
Animated Modeling Results

Application – Primary Air Ports

- Evaluate changes in primary air port design on flow patterns near the port
- Investigate the cause of high temperature excursions
**CFD Modeling of PAP Air Flow**

**Original B&W Design**

**New Design**

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**Sulfide Oxidation**

- Falling Film of Molten Smelt
- Oxidation limited by mass transfer of O₂ to surface
- Resulting heat generation as high as 1 MW/m²

*(Bird, Stewart & Lightfoot, 1960)*
Summary of PAP Analysis

- Analyses of flow and combustion around primary air ports are work-in-progress
  - CFD modeling of PAP air flow
  - Smelt flow and sulfide oxidation around PAP
  - Furnace combustion modeling
- Each of these analyses is insightful, but need to be combined into a comprehensive model
  - Detailed model of PAP coupled to boiler model
  - Effects of combustion, air flow, smelt flow, and sulfide oxidation on PAP local conditions
Application – High Temperature BL Gasifier

- Two-dimensional model takes advantage of axial symmetry
- BL heterogeneous reactions including effects of pressure
- Gas-phase reactions limited by chemical kinetics and turbulent mixing

Commercial Scale Reactor (27 atm, O₂ blown)

- Velocity
- Particles
- Temperature
- Oxygen
**Pilot Scale Reactor (27 atm, O₂ blown)**

![Diagram of Pilot Scale Reactor]

**Effect of Swirl on Flow Patterns (Streamlines)**

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**Challenges of BL Gasification**

- CFD modeling is more challenging for high-pressure, O₂ blown gasification conditions than for recovery boilers
  - high particle concentrations (2 to 65 kg/m³)
  - small mean particle diameter (30-50 microns)
  - extreme temperatures and velocity near inlet
- Enhanced transport of mass, momentum, and energy between gas and particles
- Radiation absorption and scattering coefficients are ~100 times higher than 1atm, air blown conditions
- Gas-phase chemical kinetics are strongly coupled with temperature and difficult to solve numerically.
- Simplified gas phase chemical kinetics mechanism does not predict exit composition accurately