### **Reaction Engineering International**

### **ENERGY & ENVIRONMENTAL CONSULTING**

mitted Individuals, solving challenging problems,

www.reaction-eng.com

### **REI Profile**

### **Objective: Solve Challenging Industrial Combustion Problems Using Specialist Talent & Technology**



Energy and Environmental Consulting Firm
Founded 1990, ~20 Full-Time Employees
Strong University and Specialist Affiliations
Commercial Affiliates in Taiwan, Germany, and U.K.

# **REI Expertise**

Combustion, Gasification, Fuel Conversion & Pollutant Emissions

### **Unique, Proprietary Modeling Capabilities & Tools**

- Ability to develop and apply advanced chemistry to CFD and process modeling tools
- Process model development
- "Qualified" Modelers

### R&D Testing Capabilities

- Bench-scale & pilot-scale facilities
- Field demonstrations

### Customized Software

Simplified unit-specific CFD tools, advanced process simulation software, chemical kinetic software

### **Gamma** Specialized Equipment

Development and evaluation of equipment and instrumentation concepts



Stoker, University of Utah



**Corrosion Monitoring System** 



**Burner Detail Modeling** 



**Gasifier Slagging Model** 

# **Client Base**



## **Power Generation**

- **Combustion modifications for NOx control**
- □ Air and fuel distribution/control
- □ Impacts of combustion modifications
- **Post combustion NOx control technologies**
- □ Sorbent injection (SOx, Hg, HCl control)
- **ESP** efficiency/re-entrainment
- **Scrubber efficiency**
- Boiler design



# **NOx Control Developments**

- Significant involvement in practically all DOE Coal Combustion/NOx programs over the past two decades
  - LNB optimization (NOx, Carbon-in-ash, corrosion)
  - Reburning (Traditional and FLGR)
  - SNCR
  - Fuel staging (Deep Staging, RRI, ALTA for pc and cyclones)
  - Advanced oxygen utilization
  - Biomass co-firing

### **Development of advanced CFD modeling tools:**

- Global mechanisms for gas-phase NOx chemistry in coal boilers including reburning and SNCR
- Reduced chemical kinetic mechanisms with Computer Assisted Reduction Method (CARM) for pollutant species
- Char nitrogen conversion models
- Deposition, Slagging, fouling and corrosion models
- Ultrafine particulate models including soot and ash fume
- Integration with detailed steam-side modeling

## **Selected Power Generation Clients**

#### <u>GenCos</u>

- 🖵 AEP
- Alabama Power
- □ Allegheny Power
- Alliant Energy
- Ameren
- **Aquila**
- **Basin Electric Power**
- Cinergy
- Conectiv
- Constellation Energy
- Dairyland Power
- Dominion Virginia Power
- Duke Power
- Dynegy Midwest Generation
- EME Midwest Generation
- Exelon
- **First Energy**
- Georgia Power
- Glendale Water & Power
- Gulf Power
- □ Kansas City Power & Light
- Lansing BW&L
- Louisville Gas & Electric
- □ MidAmerican Energy
- Minnkota Power Coop

#### GenCos (cont.)

- Nebraska Public Power
- NiSource
- Northeast Utilities
- NYPA
- **Owensboro Municipal Utilities**
- Ottertail Power
- Pacificorp
- Progress Energy
- PSEG
- Richmond Power & Light
- Southern California Edison
- Southern Company, Inc.
- **Springfield Utilities**
- 🖵 TVA
- UtiliCorp
- Western Kentucky Energy
- Xcel Energy

#### <u>A&Es</u>

- Black & Veatch
- Burns & McDonnell
- Jacobs Engineering
- □ Sargent & Lundy
- Washington Group

#### **Boiler OEMs**

- ABB-CE / Alstom
- 🗆 B&W
- **DB-Riley / Babcock Power**
- Detroit Stoker
- 🖵 Doosan
- **Given Setting** Foster-Wheeler

#### **APC Suppliers**

- □ Advanced Burner Technologies
- ADA-ES
- C-Entry
- **Combustion Component Associates**
- **Clean Air Engineering**
- **Clyde Bergemann**
- 🖵 CTCI
- Energy Products of Idaho
- **Given Series Provide Series and Series and**
- Fuel Tech
- 🖵 Hera
- Hamon Research-Cottrell
- Mitsubishi Power Systems
- MobotecUSA
- 🖵 Praxair
- Siemens

### **CFD Tools: GLACIER**

- **REI's in-house CFD software**
- Developed specifically for application to solid fuel fired furnaces and boilers
- Well verified in application to over 200 boilers and furnaces
- **3**D, steady-state, turbulent flows
- Coupling between turbulent fluid mechanics, radiative and convective heat transfer, homogeneous and heterogeneous reactions
- Statistical description of particles including particle dispersion
- Pollutant formation kinetics for NOx, SOx, CO, Hg and fine particles
- **Given Still evolving**



## **CFD Tools: ADAPT**

- Goal: Improved ability to solve industrial combustion problems in which disparate scales are involved or finite rate chemistry effects are critical.
- **Emphasizes improvements in:** 
  - Adaptive mesh refinement
  - Turbulence-chemistry coupling
  - Finite-rate chemical kinetics
  - Reduced mechanisms
  - Turbulent mixing parameters
  - Computational efficiency

Approach has broken new ground in analysis of ultra-low NOx burners in chemical process heaters



# **CFD Tools: Fluent**

Commercially available CFD software

Provides additional problem solving capabilities including:

- Accurate flow solver in geometrically complex volumes
- Compressible or incompressible flows
- CAD to mesh capabilities

### REI applications include:

- Air and oxy fired burners with compressibility
- Steam based soot blowing
- Air and flue gas distribution through windboxes, burner registers and SCR ductwork



Complex Geometry



Compressible Reacting Flow



165

### **CFD Tools: Barracuda**

- Dense phase flows
- Established capabilities for fluidized bed systems
- □ Bi-directional coupling
- Transient solutions
- GPU-based





www.cpfd-software.com SIMULATE > UNDERSTAND > OPTIMIZE



## **REI Developed Software**



# **Testing Capabilities**

### Major Furnace Facilities (University of Utah):

- 100 kW Oxy-fuel Combustor (~8kg/hr)
- 1.5 MW "L1500" Coal-fired Furnace (~200kg/hr)
- 300 kW Grate-fired Combustor, Spreader Stoker
- 670 kW Circulating Fluidized Bed (~85kg/hr)
- 300 kW Pressurized Entrained Flow Gasifier (~42kg/hr)
- Pressurized Fluidized Bed Gasifier (~32kg/hr)

### **Experience:**

 Burner Evaluation, Staging, Co-firing, Reagent Injection, Reburning, NOx Formation, Corrosion, Fires, Sooting



13

# **Gas Co-firing with Coal**

- REI has modeled and tested multiple implementations of gaseous fuel injection in coal burners
- Example: A comparison of waste-derived syngas injected (1) on burner center line and (2) in a conventional reburn location
  - NOx reductions as high as 46% with 23% gas
  - Impacts on carbon-in-ash and CO are critical, especially with burner injection of gas
  - Limited impact of gas composition was observed



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