NOL-TEC SYSTEMS ANALYTICAL SOLUTIONS

Introduction

Nol-Tec Systems provides analytic consulting services for combustion applications. We offer 20 years of experience in combustion and air pollution control business. Our expertise is to use Computational Fluid Dynamic (CFD) simulation to analyze, design and optimize furnace combustion and air pollution control technologies. CFD modelling can result in lower testing costs by eliminating options and verifying system details such as lance length, number of injection points, and injection location prior to testing and system design.

CFD modelling uses fluid mechanics principals to accomplish predictive analysis of fluid flows. This is done using specially design computer programs that utilize specific data structures to perform numerical analysis. This leads to simulations of the gasses and solids in a flue or exhaust stream.

Something unique to Nol-Tec Systems is the ability to simulate chemical reactions within a gas stream. This proprietary formula allows the customer to visualize and predict the overall removal of specific pollutants with given parameters. This is very important as traditional CFD modelling only displays fluid flow models which are not always indicative of effective sorbent usage. The chemistry modelling that we use was created in-house and has an accuracy of up to 93%, in comparison with field trial data. This makes CFD modelling with chemical analysis a very good option to help predict optimized parameters for dry sorbent injection (DSI) testing.

Nol-Tec Systems brings 17 years of CFD experience, which covers a full spectrum of boilers from burner design, to furnace combustion, to backend flue gas duct design and chemistry modeling. Our team has completed over 50 furnace combustion models, predominantly focusing on OFA design, SNCR design, fuel switch studies, etc.

The following information includes a brief description of CFD engineering experience utilizing lessons learned from at a power plant in the southeast United States and references for additional CFD modelling experience.

CFD Engineering Experience

Combustion Experience

Nol-Tec uses intensive CFD engineering in evaluation and design of Air Pollution Control (APC) devices. Our engineering team has developed our capabilities, and has modeled over 90 cases which cover: 1) mixing and flow dynamic modeling; 2) fuel combustion; 3) heat release; and 4) pollutant formation (i.e. NOx, SOx, LOI, CO, etc.), with fuel ranging from coal, biomass, oil to natural gas. We have also covered a wide range of boiler types from pulverized fuel (p.f.) boilers (tangential or wall-fired) with a wide range of burners to fluidized beds and stoker units.

- Nol-Tec modeling expertise covers the following chemistry associated with fuel combustion:
  - Solid fuel combustion chemistry (devolatilization, char oxidation kinetic)
  - Gas volatiles (i.e. gaseous fuel) combustion
  - CO finite rate chemistry
  - Soot formation chemistry (heavy oil combustion)
  - NOx formation chemistry (thermal NOx, fuel-N conversion chemistry)
  - SOx formation chemistry (SO2 and SO3) and reduction by limestone (CaO+SO2)
  - Urea and ammonia SNCR chemistry to reduce NOx
  - Sorbent chemistry for SO2, SO3, Mercury, and HCl capture.

DSI Experience with Chemistry Sub-model

NTS has significant modeling experience and a strong capability in evaluating design and optimization of Dry Sorbent Injection (DSI) technology for pollutants removal from flue gas. In additional to conventional flow modeling, we have incorporated a number of our in-house sorbent chemistry sub-models including:

- Hydrate lime + SO3
- Hydrate lime + HCl/SO2
- Trona + HCl/SO2
- Limestone + SO2
- Activated carbon + Hg/HgCl2

Table 1 summarizes the advantages of chemistry-based Advanced CFD modeling versus flow-only (or non- chemistry) Conventional CFD modeling, in terms of CFD outlet and evaluation capabilities. The advanced CFD model provides "real-life" predictions, including not only the mixing and flow related output that a conventional CFD can provide, but also gas species concentration and reduction predictions.

The advanced CFD model approach provides a much comprehensive and useful tool for evaluating a number of important design/operating parameters as well as sorbent properties.

Table 1: Comparison of CFD output and evaluation capability between conventional CFD and advanced CFD.

	Conventional CFD Model (Flow-only)	Advanced CFD Model (Chemistry-Based)
CFD 0utput		
Particle Concentration Distribution	✓	✓
Particle Concentration RMS	✓	✓
Particle Trajectory	✓	✓
Pollutant Species Concentration	-	✓
Pollutant Reduction	-	✓
Evaluation Capability		
Impact of Injection Strategy	✓	✓
Impact of Residence Time	-	✓
Impact of Flue Gas Temperature	-	✓
Impact of Inlet Species Concentration	-	✓
Impact of Sorbent Type	-	✓
Impact of Sorbent Size	-	✓
Impact of Sorbent Porosity	-	✓
Impact of Sorbent Surface Area	-	✓
Impact of Sorbent Flow Rate	-	✓

As an example, Figure 1 shows a using SO3 chemistry model to evaluate a DSI application at a 500 MWe coal-fired unit. Both sorbent dispersion and the SO3 species concentration and reduction are predicted by the model. Figure 2 shows the predicted SO3 reduction of DSI application on a 450 MWe unit flue gas duct with different depth of injection lances, providing a "real-life" impact when optimizing injection systems. These practically-useful results can only be obtained with chemistry sub-models.

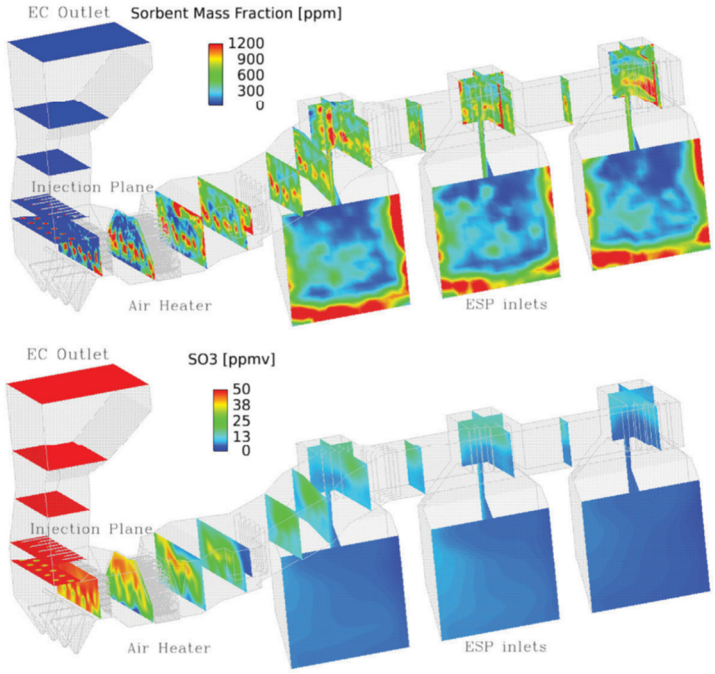

Figure 1. CFD predictions of hydrate lime particle concentration and SO3 species concentration for a DSI application on a 500 MWe unit flue gas duct. CFD Domain starting from economizer outlet to ESP inlet.

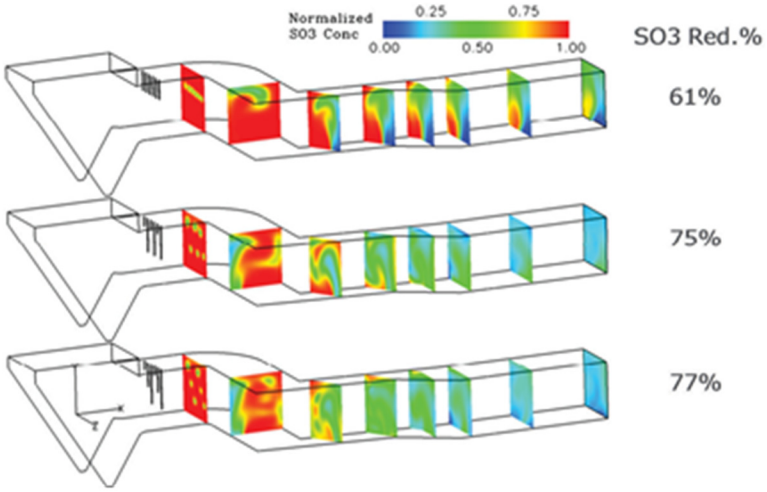

Figure 2. CFD predictions of SO3 species concentration and reduction percentage for a DSI application on a 450 MWe unit flue gas duct for three cases with different depth of injection lances.

Reference List

Below is the list of the most recent projects in these areas.

List of recent CFD projects on furnace combustion modeling for OFA and/or SNCR design

1) SNCR design on a 350 MWe coal-fired boiler in As Pontes plant in Spain
2) OFA and burner modification on 392 MWe gas-fired plant of Dong Energy in Denmark
3) OFA and SNCR design on a 500 MWe coal-fired boiler of Ruguley plant in UK
4) OFA and SNCR design on a 200 MWe coal-fired boiler of Patnow plant in Poland
5) FSI design on a 200 MWe coal-fired boiler of Stanton plant in MN
6) OFA and SNCR design on a 380 MWe coal-fired boiler of Opole plant in Poland
7) OFA and SNCR design on a 80 MWe coal-fired boiler of Wroclaw plant in Poland
8) OFA and SNCR design on a 500 MWe coal-fired boiler of Fiddlers Ferry plant in UK
9) OFA and SNCR design on a 660 MWe coal-fired boiler of Ferry Bridge plant in UK
10) SNCR design on a 660 MWe coal-fired boiler of Drax plant in UK
11) OFA and SNCR design on a 600 MWe coal-fired boiler of Longannet plant in UK
12) OFA, SNCR and FSI design on a 126 MWe coal-fired boiler of Ratts station in IN
13) SNCR design on two 670 MWe coal-fired boilers of Centralia station in WA
14) OFA and SNCR design on a 130 MWe coal-fired boiler of Uskmouth plant in UK
15) SNCR design on two 200 MWe coal-fired boiler of Morrow station in MS
16) SNCR design on a 650 MWe coal-fired boiler of Boswell station in MN

List of recent CFD projects on furnace combustion modeling for fuel switch

1) Biomass conversion on a 500 MWe coal-fired boiler of Ruguley plant in UK
2) Biomass co-firing design on a 660 MWe coal-fired boiler of Drax plant in UK
3) Biomass conversion design on a 130 MWe coal-fired boiler of Uskmouth plant in UK
4) Biomass conversion design on a 100 MWe coal-fired boiler of Wroclaw plant in Poland
5) Biomass conversion on a 500 MWe coal-fired boiler of Eggborough plant in UK
6) Biomass conversion design on a 30 MWe coal-fired boiler of Elblag plant in Poland

Nol-Tec has recently completed applications in Dry Sorbent Injection, with a specialty of incorporating unique in-house sorbent chemistry kinetic model to capture the real chemistry for DSI and ACI technologies, including:

- Hydrate lime + SO3
- Hydrate lime + HCl/SO2
- Trona + HCl/SO2
- Limestone + SO2
- Activated carbon + Hg/HgCl2

Below is the list of the most recent projects in DSI area.

List of recent CFD projects on flue gas duct modeling for DSI with chemistry sub-model

1) DSI optimization for HCl removal at St. Claire station of DTE in MI
2) DSI optimization for HCl removal at Trenton station of DTE in MI
3) DSI optimization for SO2 removal by trona at Stanton station of GRE in ND
4) DSI optimization for SO2 removal by hydrated lime at Stanton station of GRE in ND
5) DSI for SO2/HCl removal by hydrated lime at Rush Island station of Ameren in MO (dispersion only)
6) DSI optimization for SO3 removal by hydrated lime on a 450 MW flue gas duct
7) DSI design for SO3 removal by hydrated lime at Conemaugh Station of GenOn in PA
8) DSI for SO2/HCl removal by trona on a WRI (Western Research Institute) combustion facility in WY