Natural Resources Canada | Ressources naturelles Canada

CETC CANMET ENERGY TECHNOLOGY CENTRE

MODELLING

CLEAN ENERGY TECHNOLOGIES

COMPUTER MODELLING OF COMBUSTION PROCESSES

State-of-the-Art Simulations of Combustion Processes

A sophisticated combustion simulation capability is available to serve industrial needs. This modelling capability can be used to predict in service performance of combustion equipment: combustion characteristics, NO_x emissions, fuel consumption, heat transfer and fluid flow. CETC-Ottawa is committed to the advancement of combustion simulation technology through collaboration with the private sector and the research community.

CETC-Ottawa combustion simulation capability is the product of two decades of research and collaborations with the academic community and commercial software developers. Its development is based on work initiated at the University of London's Imperial College, the University of Waterloo and ANSYS Canada Ltd. It can simulate performance of utility boilers, industrial furnaces, combustors or kilns of any geometry using a wide variety of fuels.

Utilization of Combustion Modelling

Combustion simulation provides detailed information on temperatures, heat transfer, flow velocities and species concentrations. Analyses and visualization of these quantities can greatly assist:

- design analysis
- performance optimization
- evaluation of retrofit options
- identification of operational difficulties and problems
- scale up of prototypes

The CETC-Ottawa simulation capability is a decision-making tool. It can simulate real operating conditions or hypothetical scenarios, facilitating risk assessment and selection of the best option before equipment is purchased or operational changes are made.

CETC-Ottawa simulation capability is intended to generate time and cost savings. Examples of its use are given below:

Example 1: Modelling a Refinery Furnace

The combustion modelling capability has been used to understand and improve the operation of a heater (Fig. 1) used to provide energy for a catalytic cracking process in an oil refinery. In this case, uneven heating of two process fluid streams compromised production and safety. The modelling study confirmed the uneven heat distribution in the furnace and identified its cause. Further analysis of the model revealed that the performance of the unit was highly sensitive to small differences in the burners. This information prompted the furnace operators to reconfigure the burner firing rates, leading to improved heat distribution. The corrections resulted in cost savings of $100 000 – $300 000 per year (payback on cost of the study within three months).

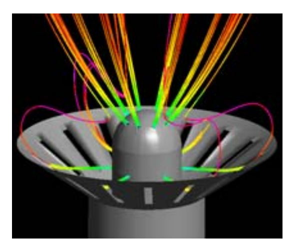

Fig. 1: Refinery furnace and detailed burner fuel flow model

Canada

CETC – OTTAWA
CANMET Energy Technology Centre
Natural Resources Canada
1 Haanel Drive, Ottawa, Ontario K1A 1M1
Tel: (613) 996-8693 **Fax:** (613) 995-9584
www.cetc.nrcan.gc.ca

Example 2: Innovative Combustion Technology

In collaboration with other researchers at CETC-Ottawa, combustion modelling has been used to test several different design concepts for a new pure oxygen-based firing process. This allowed the testing of radically different designs before moving on to physical prototyping and experimentation. Using this modelling capability, an optimized design concept was identified for fabrication. Further experimentation validated the predicted model results, and a burner for an innovative combustion technology was developed. A comparison of different burner designs is shown opposite. (Fig. 2)

Example 3: Reducing Boiler Emissions

One of the undesirable emissions that electric power-generating utilities are aiming to reduce from fossil fuel-fired boilers is NO_x. This can be done by regulating the combustion chemistry of the boilers' near burner regions. Load schedules, burner configurations, air flow rates and fuels burned collectively govern the production of NO_x emissions. Optimal conditions for minimizing NO_x production, therefore, are different for each boiler. CETC-Ottawa staff designed a NO_x model for power utilities.

CETC-Ottawa staff validated the model by comparing simulated results with those actually obtained. See Figure 3. Staff used three different coals in a pilot-scale boiler equipped with a low-NO_x burner. A fourth experiment compared results obtained for operating conditions intended to produce relatively high NO_x emissions.

CETC-Ottawa simulation capability has since been used to evaluate the performance of full-scale utility boilers in Alberta, Saskatchewan, Ontario, Nova Scotia and China. The results from this work enable CETC-Ottawa staff to develop and test strategies for reducing NOx emissions and improving boiler performance.

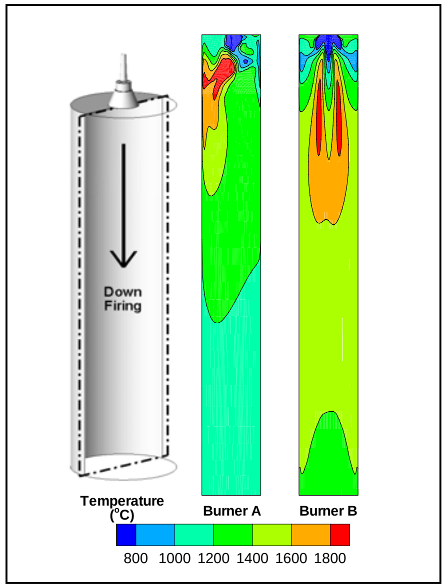

Fig. 2: Comparison between temperature profiles for different burner designs

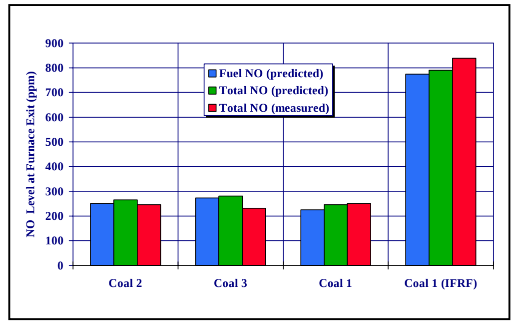

Fig.3: Comparison between Measured and Predicted Total NO at a Furnace Exit for 3 Coals Tested at CETC-Ottawa & IFRF (Courtesy of the Canadian Electricity Association)

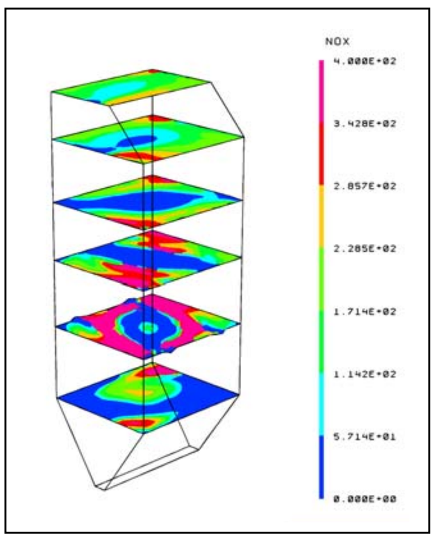

Fig.4: NO_x Concentration (in ppm) at Selected Sections inside a Utility Boiler (Courtesy of the Canadian Electricity Association)

Using CETC-Ottawa Simulation Capability

Best results are achieved when the model is customized to client needs. Combustor geometry, fuel type, operating conditions and the parameters to be studied must all be addressed correctly if useful and meaningful results are to be obtained. CETC-Ottawa's experts have the necessary familiarity with the computer codes as well as the required understanding of combustion science and technology. CETC-Ottawa staff can customize the software to meet the client's needs.

Invitation to Work with Us

We are interested in collaborating with you. Please contact the Business Office to discuss your particular needs.

☎ (613) 996-8693
✉ cetc-bdo@nrcan.gc.ca

For Further Information Please Contact:

Eddy Chui, PhD, PEng
Research Scientist
☎ (613) 943-1774
✉ echui@nrcan.gc.ca

CANMET Energy Technology Centre - Ottawa
Natural Resources Canada
1 Haanel Drive
Nepean, Ontario, K1A 1M1
Canada

cetc.nrcan.gc.ca