Computer Modelling of Combustion Processes

State-of-the-Art Simulations of Combustion Processes

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

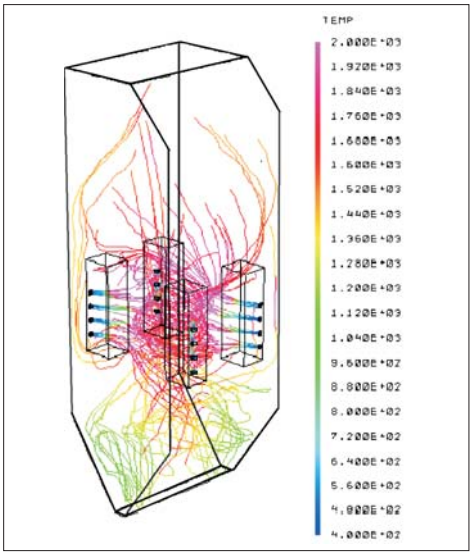

Fig. 1: Coal Particle Trajectories inside a Utility Boiler (Colour Represents Particle Temperature)

TASCflame is the product of a close working relationship between the CANMET Energy Technology Centre (CETC) and Advanced Scientific Computing Ltd. The program is the result of more than twenty years of research and development based on work initiated at the University of London's Imperial College and the University of Waterloo.

TASCflame is versatile. It can simulate performance of industrial boilers, furnaces or kilns of any geometry under a wide variety of fuels.

Typical Applications

TASCflame provides detailed information on temperatures, flow velocities and species concentrations. It is well suited for:

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

TASCflame is a decision-making tool. It can simulate hypothetical scenarios, enabling selection of the best option before equipment is purchased or operational changes are made.

TASCflame saves time and money. Examples of its use are given below:

Example 1: Improving Product Yields

A company producing carbon black wanted to increase production yields. It was contemplating new designs for furnace components and needed reliable information on their performance. CETC staff used TASCflame to simulate the operation of the production furnace. Analysis of the results showed significant increases in predicted yields. The simulation also achieved substantial savings over the costs of obtaining experimental data for the same purpose.

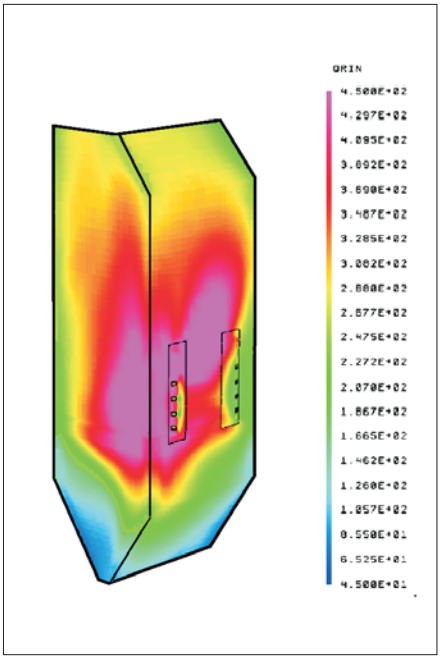

Fig. 2: Incident Radiant Heat Transfer on a Utility Boiler Wall

Example 2: Scaling-Up Equipment Designs

An equipment manufacturer is designing a novel billet reheat furnace and has built and tested a prototype. The designer now needs to know how a full-scale unit would perform. CETC staff use TASCflame to simulate the performance of the prototype and compare the results to test data. Once they have confidence in the computer model, staff can simulate and predict the performance of the full-scale unit. The simulation enables design flaws to be identified and corrected prior to scale up.

Example 3: Reducing NO_x Emissions

Electric power-generating utilities are aiming to reduce NO_x emissions from fossil fuel-fired boilers. They plan to do so 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 staff designed a NO_x model for use with TASCflame.

CETC 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

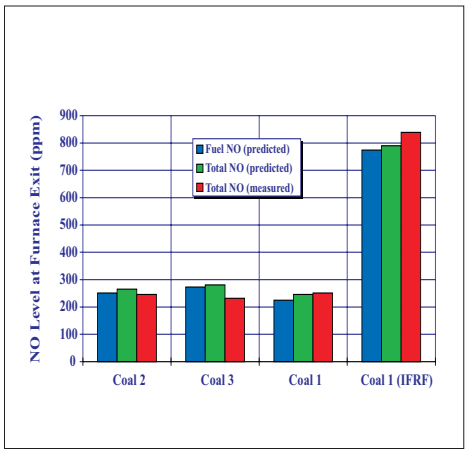

Fig.3 Comparison between Measured and Predicted Total NO at Furnace Exit for 3 Coals Tested at CETC & IFRF (Courtesy of the Canadian Electricity Association)

operating conditions intended to produce relatively high NO_x emissions.

TASCflame has since simulated the performance of two full-scale utility boilers. The results from this work enables CETC staff to develop and test strategies for reducing NO_x emissions and improving boiler performance.

Using TASCflame

Best results are achieved when TASCflame 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's experts have the necessary familiarity with the computer code as well as the required understanding of combustion science and technology. CETC staff can customize the software to meet the client's needs.

Clients may also license the technology for their own use from Advanced Scientific Computing Ltd., of Waterloo, Ontario, Canada.

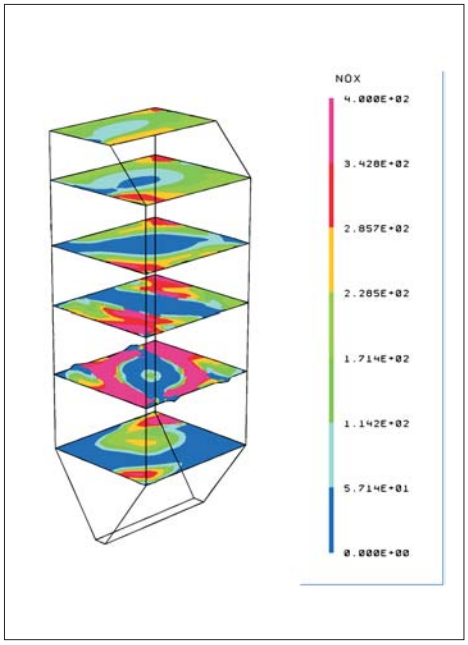

Fig.4 NO_x Concentration (in ppm) at Selected Sections inside a Utility Boiler (Courtesy of the Canadian Electricity Association)

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