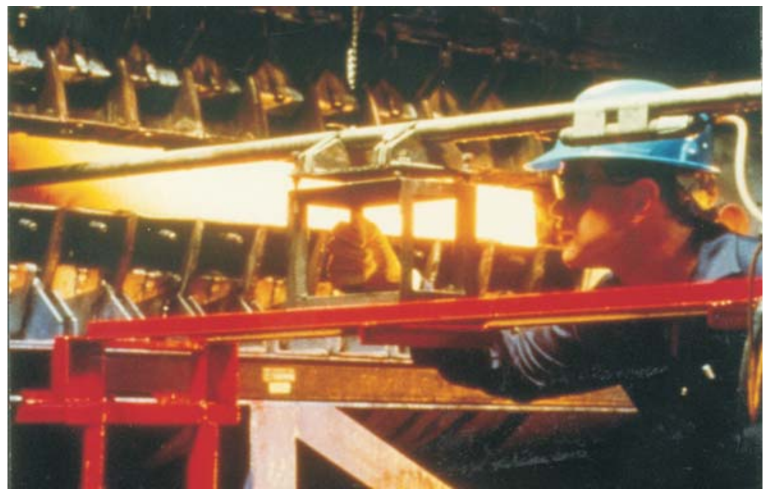
Measurement Capabilities for Combustion Technologies and Simulation Code Validation

The CANMET Energy Technology Centre (CETC) develops and evaluates new combustion technologies for a wide variety of applications. Since 1968 CETC has collaborated with members of the private sector to study combustion related phenomena at the bench and pilot scales to minimize the risk in applying new technology to full-scale operation; optimize the operation of existing combustion equipment; and demonstrate the validity of predictions of the CETC simulation codes.



Flame Probing

The Facilities

The pilot-scale research boiler (PSRB) and the flame research tunnel furnace (FRTF) allow for the study of combustion phenomena at the pilot-scale[1]. Both furnaces have an internal volume of about 4.7 m^3, a firing rate of about 0.7 MW (2-3 million BTU/hr) and can handle any solid, liquid or gaseous fuel. The PSRB is used to study overall combustion performance. The FRTF, on the other hand, allows for detailed study of the flame and its characteristics. Another bench-scale furnace, the entrained flow reactor (EFR), is used to study high temperature reactions in flames of solid fuels and absorbents.

Conventional intrusive probes are primarily used to measure composition, temperature and velocity inside the flame research tunnel furnace. In addition to conventional species (O_2, CO_2 and CO), other species such as N_2O, NO_x, SO_x, hydrocarbons (C_xH_y), Polyaromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and transient species such as HCN and NH_3 are also measured.

Non-intrusive techniques, including those listed in the following table, are used in the near burner region where conventional probes would disturb the flame. These measurement techniques, except for total heat flux, depend upon the study of

[1] ***Pilot-scale research boiler and flame research tunnel furnace are described at length in separate factsheets.***

Advanced Combustion Technologies

Non-Intrusive Flame Measurement		
Technique	***Purpose***	***Comments***
2 Radiometer	incident heat flux	instantaneous
Narrow Angle Radiometer	flame emissivity	instantaneous
CARS	gas temperature composition	instantaneous
Laser Sheet Illumination (LSI)	burner aerodynamics	instantaneous
Emission Spectroscopy	flame chemistry studies	instantaneous
Cooling Circuits	total heat flux at wall	mean value

light emitted from the flame or from the interaction of laser beams in the flame. The techniques identified as "instantaneous" allow turbulence to be measured in the fields of flow.

Proving Technologies

CETC's flame measurement capabilities and pilot-scale furnaces have been used successfully by industry. The following three examples identify how CETC can work with the private sector.

Scenario A

Electrical utilities in Canada need proven computer simulation technology to predict the combustion performance and NO_x formation in full-scale utility boilers. They will use this simulation technology to optimize the performance of existing boilers and to evaluate new technology.

CETC staff developed the simulation technology. They also validated it against predicted values using results obtained from critical measurements made during experiments in the pilot-scale tunnel furnace. The following graphs compare the predicted and measured concentrations of NO_x (see Figure 2) and its precursors HCN and NH_3 (see Figure 1).

Scenario B

A new-laser based measurement technique (CARS) is to be used to measure the gas temperature in the near burner region of flames in the flame research tunnel furnace. Industrial partners require that conventional (suction pyrometry) and CARS measurements be consistent. Experiments were undertaken using CARS and suction pyrometry in coal and oil flames. The mean CARS temperatures were the same as those measured by suction pyrometry; however, in addition to the mean temperature, the fluctuating component and turbulence properties of

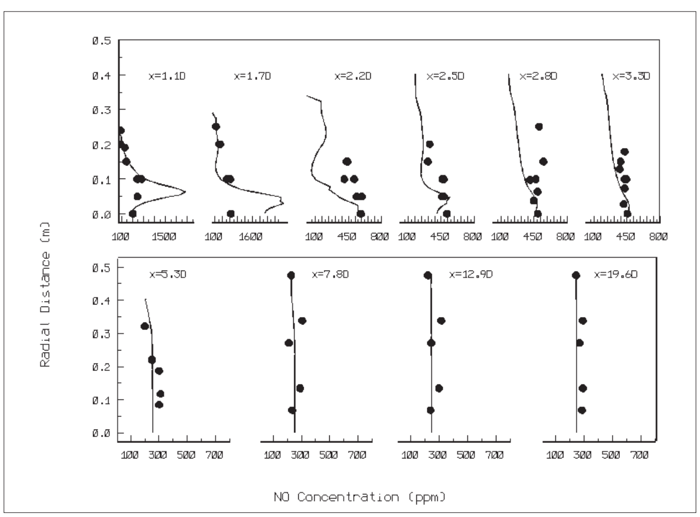


Fig. 1

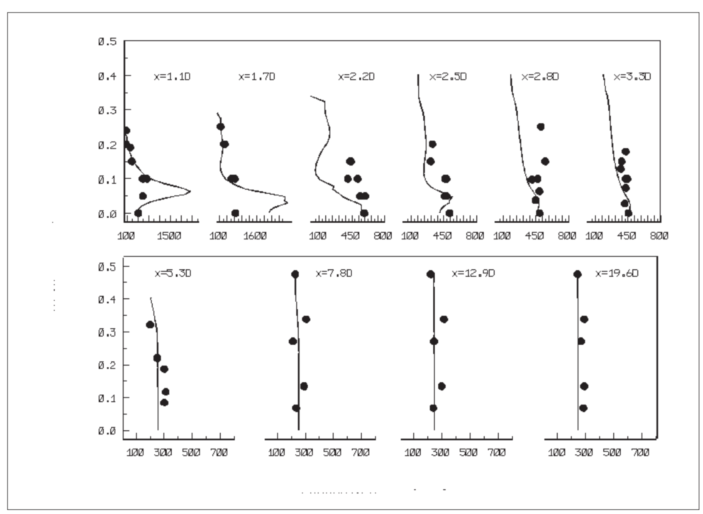
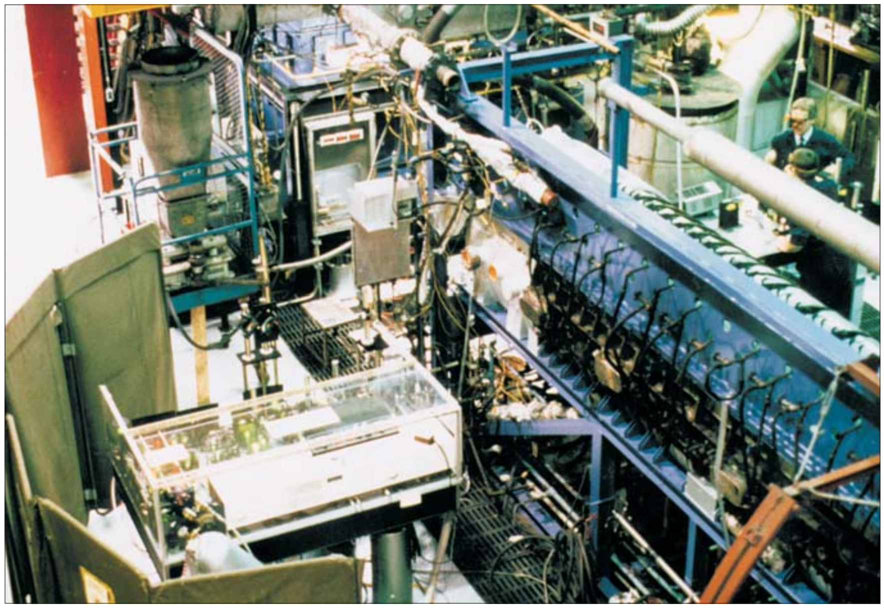


Fig. 2

temperature were also available from the CARS measurements.

Scenario C

A manufacturer wanted to design a new incinerator for production of carbon black and to do so needed to know more about the product's combustion characteristics. CETC staff measured its kinetic parameters of combustion in their entrained flow reactor. Results from this work serve in part as a basis for the incinerator's design.



CARS Measurements

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