D I A L
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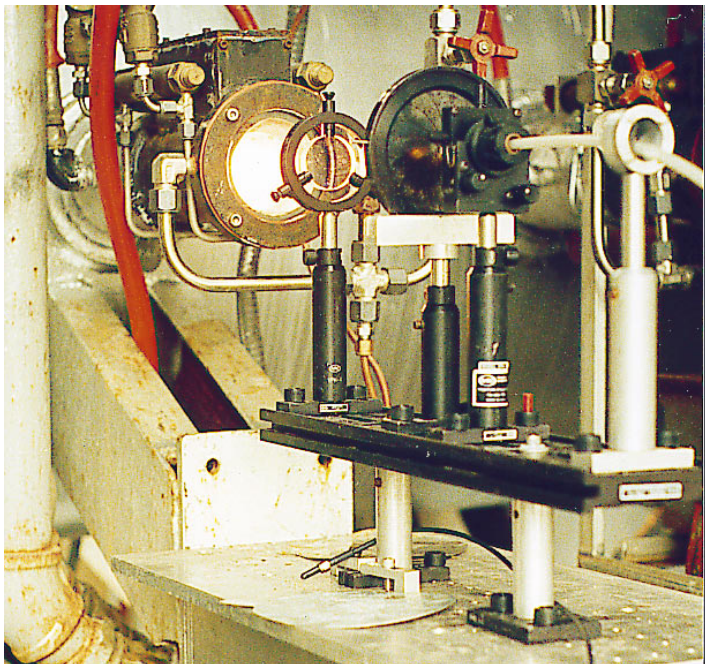
Multiwavelength Emission Absorption Spectroscopy (MEAS)

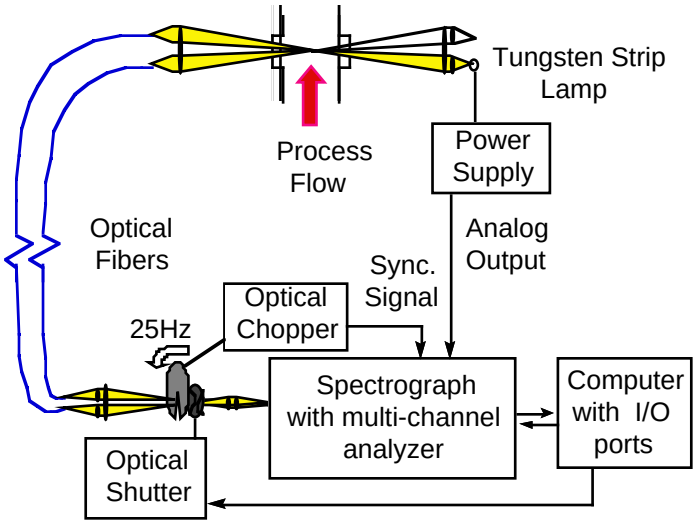
A combination of modern spectroscopic instrumentation with classical atomic spectroscopy and a novel measurement technique has produced an instrument for highly accurate measurements of temperature and species concentration in high temperature process flows (> 1500 K). The non-intrusive optical instrumentation and measurement technique are robust and applicable to large-scale industrial processes, notably particle laden flows. Successful application to coal-fired combustion flows has demonstrated minimization of errors due to slight misalignments, dirty optical windows, particle cloud effects, making the instrument suitable for long-term monitoring and/or process control. The instrument is superior in accuracy to conventional diagnostics, e.g., aspirated thermocouples, and can be applied to gas stream with temperatures well above that possible with conventional diagnostics.



MEAS optics on combustion facility.

Description

Line reversal is a classical technique for very accurate gas temperature measurements based on emission/absorption of light at an atomic resonance line. Often, temperature measurements are made by employing naturally occurring sodium or potassium atoms and observing the well-known D-line in the flame. The technique provides not only an easily implemented measurement of temperature but also the concentration of the atomic emitter.



MEAS instrument diagram.

With little additional complexity, broadband particle effects and transmission losses, can be added to the analysis. Spectroscopic measurements at two wavelengths are sufficient to find the gas temperature and atomic density. Fluctuating flows require simultaneous as well as multi-wavelength light measurements for accurate results. Selection of optimum measurement wavelengths is computer automated and is the key to the accuracy of the instrument over wide ranging flow parameters. On stable laboratory

flames, temperature measurements can be made with an accuracy of 10 K.

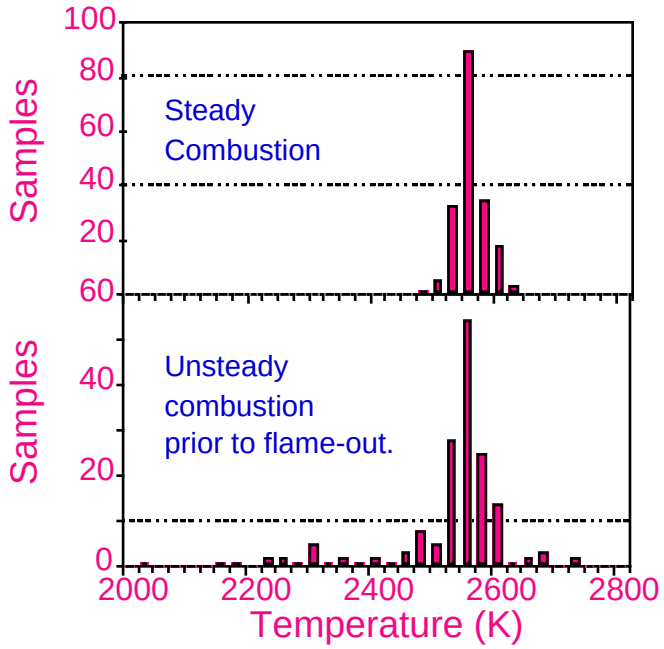


Figure 3. MEAS temperature measurements of a coal-fired combustion flow as probability distribution functions illustrating stable and unstable combustion just prior to an unintended flame-out.

Spectrally resolved measurements on the atomic lines are used to provide an accurate measure of the hot core temperature in a boundary layer pipe flow. Example combustion temperature measurements are shown in Figure 3. For certain flows, a thermal profile across the optical path may be obtained from detailed lineshape analysis, see Figure 4. Current work includes the development of a fiber optic probe for spatially resolved measurements in large-scale industrial boilers (> 4 ft) or in optically thick flows such as incinerators.

Instrument Capabilities

- Temperature range, 1400 - 3000 K.
- Accuracy, 10 K.
- Time resolution of 1msec and data collection rate > 1 Hz.

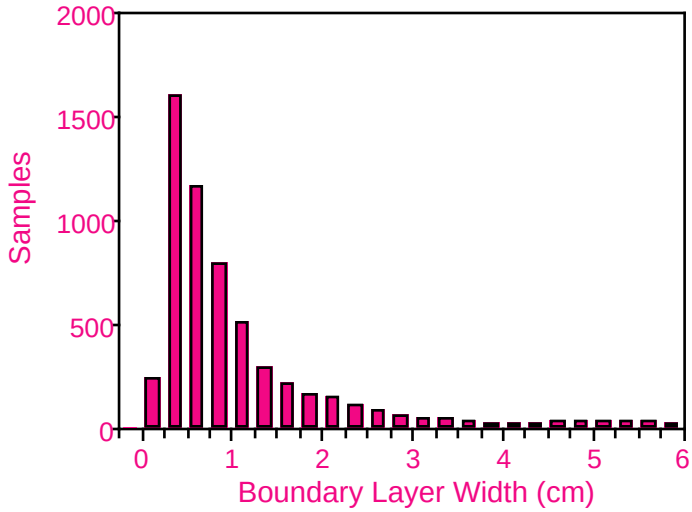


Figure 4. MEAS measurements of the thermal boundary layer width in a 12 cm diameter pipe flow found from lineshape inversion.

On-Site Applications

The MEAS instrument was used successfully over a decade for measurements of temperature, atomic potassium density, electron density and conductivity in prototype scale coal-fired magnetohydrodynamic facilities. Many of the tests involved monitoring over several hundreds of hours. The instrument has also been used for proprietary measurements of flame temperature in an industrial natural gas/oxygen fired furnace.

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