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Optical heat flux and temperature measurements on a 100 kW oxy-fuel combustor

Authors: Teri Draper, Pal Toth, Terry Ring and Eric Eddings

Optical measurements were taken on a larger-scale, 100 kW oxy-fuel combustor located at the University of Utah. The fuel used was a bituminous, pulverized, Utah Sufco coal.

These measurements consisted of: a mid-wave infrared (MWIR) camera to measure radiative heat flux and temperature; a synchronized high-speed, visible camera with an image splitter and narrow-band filters to facilitate two-color pyrometry to measure temperature and soot concentration, and narrow-angle radiometers to measure incident radiative heat flux.

The purpose of this campaign was to examine the reproducibility of the measurements over time and to provide a comparison between different methods of heat flux and temperature measurement. Thus, a single operating condition was used and 15 separate measurements were made over a period of three days. Data from these three techniques were taken simultaneously, with a primary purpose of validating combustion models. Thus, a quantification of the variability in the measurements over time was of high interest.

All three measurement techniques proved fairly stable over the 15 conditions examined. Each of the techniques had standard deviations over the 15 runs that were less than 1% of their respective mean values. This limited variability shows a high degree of precision with the measurements. The result also implies a high degree of sustained steady operation over several days for the combustor system and the flame itself, which can be difficult to achieve with larger pulverized-coal-fired test furnaces.

It was found that the radiometer and infrared heat flux measurements were very similar (within 1%) after correcting the infrared data for differences in the radiating background material between the two techniques. The correction was necessary since simultaneous measurements required that the two techniques utilize different furnace ports with different radiative backgrounds. The two-color measurements yielded temperature values approximately 200 K above those obtained from the MWIR camera and radiometer data; however, the two-color technique measured the hottest part of the flame while the other two techniques measured a cooler part of the flame, again due to simultaneous measurements occurring in different ports. Thus, this discrepancy is expected.