UV-based Temperature and OH Concentration Sensor

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Overview

Two novel, laser-based sensors employing ultraviolet (UV) wavelengths are developed and applied to measure time-resolved temperature and OH concentration in a pulse detonation tube. These results, along with pressure data, are employed to evaluate two computational simulations utilizing different chemistry and heat transfer models to predict pulse detonation engine (PDE) flowfields.

The first sensor applies 266 nm and 306 nm UV laser absorption to infer temperature from 2000K to 4000K owing to broadband CO2 absorption. These results represent the first thermometry based on line-of-sight, cw UV laser absorption by CO2. The second sensor utilizes a single 306 nm UV laser to probe an individual OH absorption feature. Time-resolved OH concentration is inferred from the measured absorption, temperature, and pressure. These two sensors provide microsecond time-resolved measurements, over a dynamic range of temperature and pressure (0.5-30 atm and 2000-4000K), of two important parameters needed for evaluation of PDE computational models.

The first computational model evaluated utilizes a frozen gas composition assumption; the second model incorporates finite-rate chemistry and includes losses due to heat transfer and friction. The results show that the frozen gas composition simulation can successfully predict temperature and pressure profiles, although the agreement is artificial in that inclusion of heat transfer effects would negate this agreement. The simulation including finite-rate chemistry and no heat transfer overpredicts the measured temperature and OH concentration. However, with the proper inclusion of losses due to heat-transfer, the finite-rate chemistry code accurately predicts all three measured parameters. We conclude that both finite-rate chemistry and heat transfer are important for correct modeling of PDE flowfields.

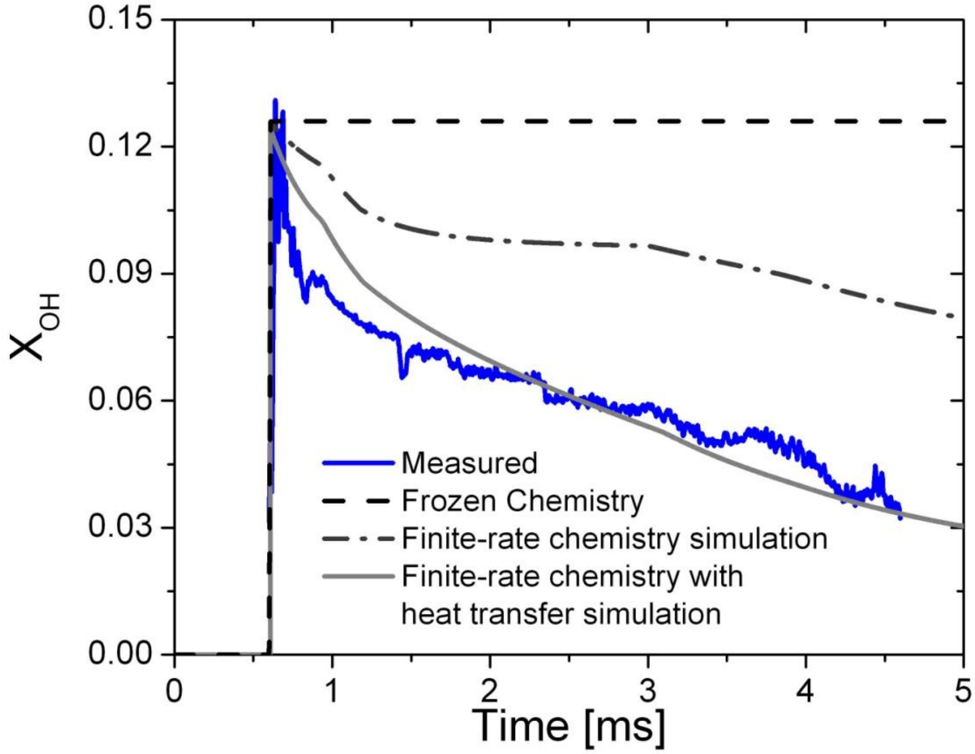

Figure 1: OH mole fraction (from measured absorption, temperature, and pressure) compared to two simulation results. Both frozen chemistry simulations yield a constant value of X_{OH}=0.126

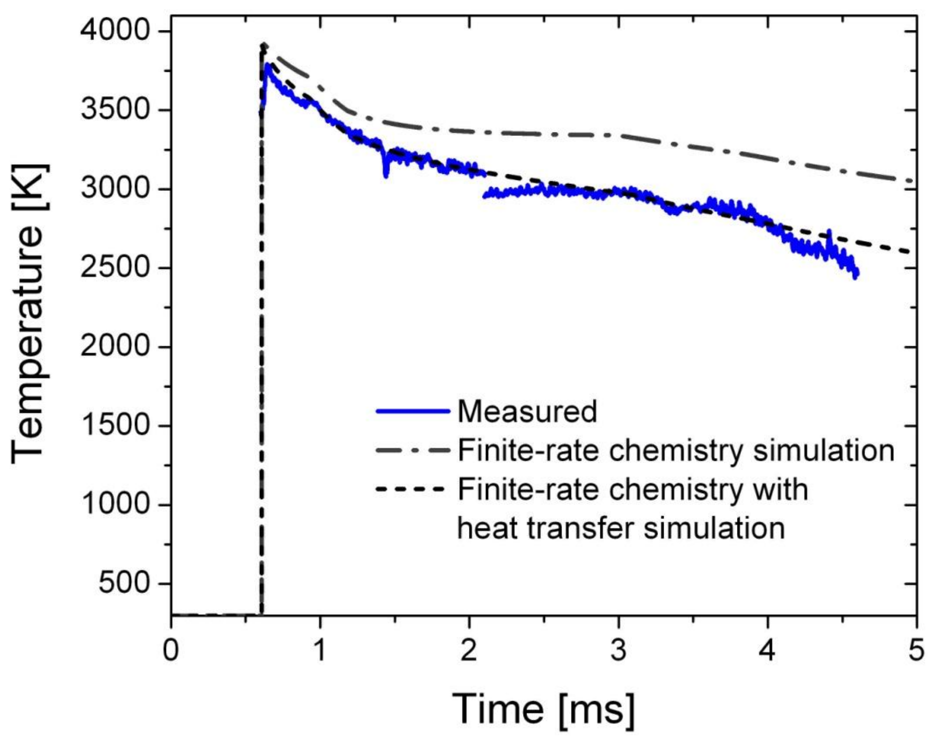

Figure 2: Inferred temperature from measured CO2 absorption and pressure compared to two finite-rate chemistry simulation results