Comment and Reply on "Quantitative Measurements of Enhanced Soot Production in a Flickering Methane / Air Diffusion Flame"

by C. R. SHADDIX, J. E. HARRINGTON AND K. C. SMYTH

Editors' Note: The following comment and reply refer to Ref. 1 which is a regular paper presented at the Twenty-Fifth Symposium (International) on Combustion, Irvine, California, August 1994. Thus, the format of the following comment and reply is in the Symposium format rather than the conventional journal format.

REFERENCE

1. Shaddix, C. R., Harrington, J. E., and Smyth, K. C., *Combust. Flame* 99:723–732 (1994).

N. Tait. Cranfield University, UK. What would you estimate was the smallest soot particle size that your LII measurements were sampling?

Is it possible that some of the disagreement between your LII and absorption measurements in the interior of the flame is due to the biasing of the LII measurements to large particles? The smallest particles will not reach vaporization temperatures and the largest ones will cool more slowly after the laser pulse giving enhanced signal during the long gate.

Authors' Reply. The analyses of Melton [30] and Tait and Greenhalgh [28] indicate that a short temporal gate is desirable to minimize biasing of the LII measurements towards the largest particles. However, for our lightly sooting methane flames a gate duration of 100 ns was required in order to obtain sufficient signal-to-noise. Given the observed agreement between HeNe extinction measurements and LII signals (calibrated at a height of 50 mm) in the peak annular soot region at H = 30 mm (Fig. 3), it is apparent that the LII measurement is sampling all of the soot at this position, which has a calculated optical diameter (for a monodisperse distribution) of 39 nm (Table I). Furthermore, towards the centerline at H = 60 mm the calculated particle diameter is 32 nm and the LII and extinction are in reasonable agreement. At the lowest soot measurement height of 20 mm (not shown in Fig. 3 due to space constraints), the calibrated LII signal is only about half of the extinction soot volume fraction. On this basis, it appears that soot particles with optical diameters of about 30 nm represent the lower size limit for effective detection under our experimental conditions. We have recently investigated the effect of temporal gate duration on the LII signal measured in a steady ethylene/air flame using gates of 25, 100, and 1100 ns, all opening coincident with the laser shot. Towards the top of this flame, the short (25 ns) gate gave consistently larger relative signals (by 10–25%) in interior soot regions; in these same regions the long (1100 ns) gate gave 10–35% smaller relative signals than those measured using the 100 ns gate.

Based on these considerations, it is certainly possible that some of the disagreement between the LII and extinction measurements may be due to limited detection by LII of the smaller soot particles in interior regions. Other sources of disagreement are (1) radial variation in the measurement sensitivity of the LII signal due to laser focusing/depth-of-field effects (which we recently determined lead to a 10% decrement in signal along the burner centerline), (2) slight differences in the measurement heights sampled with the two methods (which becomes very important near the top of the flame where the soot field is rapidly evolving), and (3) increasing uncertainty in the extinction measurement in interior regions due to possible contributions from large molecule absorption, laser baseline drift (which could not be completely eliminated as an error source for these small signals), and the uncertainties in tomographic inversion, which increase towards the centerline.

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