Effects of Gas Density and Vaporization on Penetration and Dispersion of Diesel Sprays

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Abstract:
Ambient gas density and fuel vaporization effects on the penetration and dispersion of diesel sprays were examined over a gas density range spanning nearly two order of magnitude. This range included gas densities more than a factor of two higher than top-dead-center conditions in current technology heavy-duty diesel engines.

The results show that ambient gas density has a significantly larger effect on spray penetration and a smaller effect on spray dispersion than has been previously reported. The increased dependence of penetration on gas density is shown to be the result of gas density effects on dispersion. In addition, the results show that vaporization decreases penetration and dispersion by as much as 20% relative to non-vaporizing sprays; however, the effects of vaporization decrease with increasing gas density.

Characteristic penetration time and length scales are presented that include a dispersion term that accounts for the increased dependence of penetration on ambient density. These penetration time and length scales collapse the penetration data obtained over the entire range of conditions examined in the experiment into two distinct non-dimensional penetration curves: one for the non-vaporizing conditions and one for the vaporizing conditions. Comparison of the two non-dimensional penetration curves to a theoretical penetration correlation for non-vaporizing sprays helped isolate and explain the effects of droplets and vaporization on penetration. The theoretical penetration correlation was derived using the penetration time and length scales and simple model for a non-vaporizing spray that has been previously presented in the literature. The correlation is in good agreement with the non-vaporizing data from this experiment and other commonly quoted penetration data sets. It also provides a potential explanation for much of scatter in the penetration predicted by various correlations in the literature.