LAMINAR FLAME PROPAGATION IN FUEL DROP SUSPENSIONS

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Combustion of liquid-fuel sprays and suspensions is one of the topics attracting growing attention of research scientists and engineers in view of stringent requirements to exhaust emissions of transportation engines. Mathematical modeling provides better understanding of the encountered phenomena and allows for optimization of spray and suspension parameters to achieve the maximum combustion efficiency at minimum pollutant yields. The objective of this study is to assess the effect of mean drop size in a polydisperse suspension on the laminar burning velocity and pollutant (CO, NOx, and soot) emission indices.

Laminar flame propagation in a fuel drop suspension is modeled by the set of one-dimensional mass and energy conservation equations coupled with continuity equations for 10 species participating in 10 fuel oxidation and pollutant formation reactions. The main assumption of the approach is that the rate of fuel conversion to CO and H_2O in a two-phase flame is governed by the d^2-law of drop gasification. The rates of other gas-phase reactions are governed by Arrhenius-type dependencies.

Various drop size distributions of a Rosin–Rammler type were tested in the analysis. It has been shown that the Sauter mean diameter can serve as a representative mean drop size for simulating flames in polydesperse drop suspensions in terms of the flame in a mono-size suspension.

Figures 1*a* to 1*d* compare the predicted structures of atmospheric premixed (*g*) and two-phase (*d*) flames in terms of spatial profiles of temperature (*a*), as well as CO (*b*), NOx (*c*), and soot (*d*) concentrations.

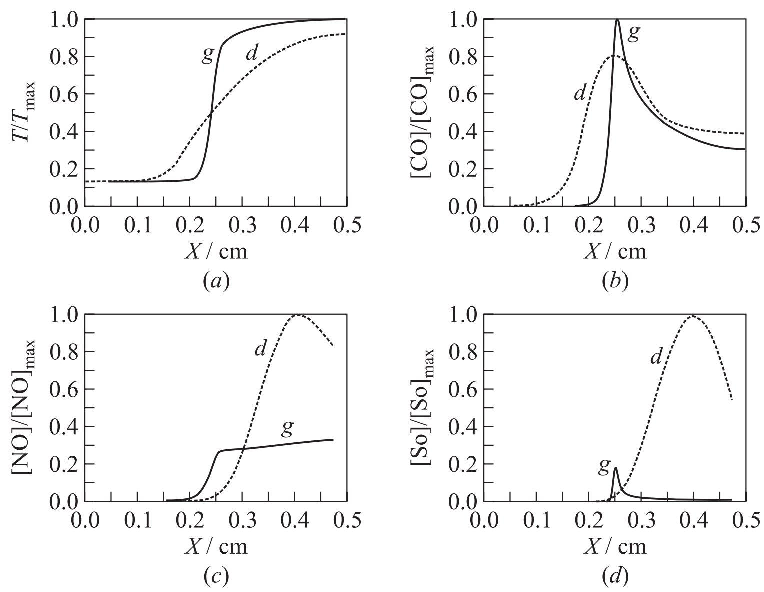

Figure 1 Predicted structures of atmospheric premixed (g) and two-phase (d) flames in terms of temperature (a), CO (b), NO (c), and soot, So, (d) concentrations. $T_{\max} = 2247$ K, $[CO]_{\max} = 0.38\%$, $[NO]_{\max} = 144$ ppm, and $[So]_{\max} = 0.93\%$

In this example, n-tetradecane is taken as a fuel, and the mean drop diameter is equal to 50 μm. The two-phase flame exhibits a wider reaction zone and higher yields of CO, NOx, and soot. Computational results show that emission indices of the combustion process are better for sprays with a smaller mean drop size.

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