Paper ID: 12922
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MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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DIMENSIONAL SCALING OF QUENCHING FOR FLAME PROPAGATION IN RANDOM MEDIA

Abstract

The propagation of flames through arrays of randomized point-like heat sources embedded in an inert media is studied both analytically and computationally as a model system for understanding combustion in heterogeneous media. For the situation where the reaction time of the sources is comparable to or less than the time for heat diffusion between sources, the flame propagates in a discrete regime, and the classical continuum solution can be shown to be no longer applicable. The propagation of the flame can be solved by superimposing the solution for an individual active source (Green's function) to find the temperature field in the media, and new sources activated if they reach a specified ignition temperature. The limits to the propagation of the flame in this regime as well as the velocity of the flame are examined. Specifically, the combinations of characteristic ignition temperatures and particle concentration that can support propagation are investigated. Of particular interest is the scaling of these results between finite-sized two-dimensional rectangular slab-shaped clouds and axisymmetric cylindrical clouds, and comparing them with the classical results from laminar flame theory with heat losses. Experimentally, the discrete regime of flame propagation has been investigated using iron particles in dilute suspensions in low-diffusivity oxidizer (oxygen/xenon mixtures). Due to the experimental difficulty of obtaining a uniform dispersion of dust and laminar flame propagation as a result of sedimentation and buoyancy effects, the experiments are carried out in a reduced gravity environment onboard a parabolic flight aircraft. The flames are passed through parallel quenching plates and honeycomb arrays of quenching channels in order to determine the flame speed and propagation limits. Experiments on parabolic aircraft prove to be sensitive to the quality of reduced gravity and the results are influenced by g-jitters. The status of development of a follow-on experiment for flight on a suborbital sounding rocket, capable of longer duration and higher quality reduced gravity, will be presented.