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PROPAGATION OF MAGNESIUM DUST FLAMES IN REDUCED-GRAVITY

Abstract

Flame propagation in magnesium dust clouds was studied in a reduced-gravity environment. Due to the difficulty of dispersing a uniform cloud of particles, fundamental parameters of metal dust flames such as the laminar flame speed and the quenching distance are absent from the literature. Large particles are subject to fast settling rates on the order of or exceeding flame speeds, rendering laminar flame propagation only possible with fine particles (less than 5 microns) during on-ground experiments. In the present work, experiments were performed onboard the National Research Council (NRC) Canada Falcon-20 parabolic flight aircraft using 38 to 75 micron-sized magnesium particles. Magnesium was selected as a fast-reacting and highly energetic fuel to study the discrete regime of flame propagation characterized by particles burning rapidly relative to the characteristic heat transfer time between particles. The particle dispersion was performed inside of a transparent glass tube (ID = 48mm, L=70cm). Ignition of the mixture was performed at the open end of the tube by an electrically-heated wire, initiating a flame that propagated through a mixture of air-magnesium particles. Equally-spaced plate assemblies forming rectangular channels were placed inside the tube. The quenching distance was determined as being the minimum channel width through which a flame could successfully propagate. A high-speed video camera was used to measure the flame speed in the open tube and in the channels. The temperature of the flame was determined from the emission spectra of the flame recorded by a spectrometer. In-situ, non-disturbing dust concentration measurements were derived from the image capture and subsequent count of particles illuminated by a thin laser sheet. Results were compared with an analytic model of the three-dimensional flame developed to capture both the discrete nature of heat release of the flame and the random particle distribution of the mixture. Satisfactory agreement was found between the model and the experiments. However, quenching of slow propagating flames indicated that the flame remained affected by residual g-jitter levels (0.02-0.07g's) from the reduced-gravity environment.