# NNC04GA13G: A NUMERICAL INVESTIGATION OF THE EXTINCTION OF LOW STRAIN RATE DIFFUSION FLAMES BY AN AGENT IN MICROGRAVITY

**Ishwar K. Puri**

***Department of Mechanical Engineering (M/C 251), University of Illinois at Chicago, Chicago, Illinois 60607-7022***

Unwanted fires typically occur due to nonpremixed combustion when an oxidizer is placed in contact with a fuel and there is accidental ignition. In a microgravity environment, a fire will occur at a low strain rate, possibly when a random fuel stream from a leak or a pyrolytic region mixes with calm air. Therefore, knowledge of the flammability or extinction conditions of low strain rate flames is important. The microgravity environment is suitable for understanding both the processes involved in and the extinction limits in spacecraft-type fires.

There are two major processes involved in the flame suppression at low strain rates: dilution by inert agents and thermal radiation. Suppression experiments have shown that a moderate strain rate nonpremixed flame necessitates larger agent concentrations than its high strain rate analog, thus suggesting a strengthening of the flame when it reaches low strain rates. This occurs until a critical point when the flame suddenly weakens and then extinguishes rapidly. The effects of flame inhibitors are well known, i.e., cooling of the mixture due to the specific heat of the agent, and a decrease in key reaction rates due to the temperature decrease, which synergistically impact upon the heat release.

Thermal radiation has traditionally been investigated in large-scale fires. However, due to the absence of buoyancy effects, the consequences of radiation are amplified in microgravity for small-scale flames, since the convection heat transfer becomes less relevant. In many cases radiation becomes a key player in determining combustion and extinction behavior. Radiation lowers the flame temperature due to heat loss, which changes the flame structure. The flame can be quenched if the heat loss is sufficiently large.

Our goal has been to investigate the influence of both dilution and radiation on the extinction process of nonpremixed flames at low strain rates. Simulations have been performed by using a counterflow code and three radiation models have been included in it, namely, the optically thin the narrowband, and discrete ordinate models. The counterflow flame code OPPDIFF was modified to account for heat transfer losses by radiation from the hot gases. The discrete ordinate method (DOM) approximation was first suggested by Chandrasekhar for solving problems in interstellar atmospheres. Carlson and Lathrop developed the method for solving multi-dimensional problem in neutron transport. Only recently has the method received attention in the field of heat transfer. Due to the applicability of the discrete ordinate method for thermal radiation problems involving flames, the narrowband code RADCAL was modified to calculate the radiative properties of the gases.

A non-premixed counterflow flame was simulated with the discrete ordinate method for radiative emissions. In comparison with two other models, it was found that the heat losses were comparable with the optically thin and simple narrowband model. The optically thin model had the highest heat losses followed by the DOM model and the narrow-band model.

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