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Flame characterization by PIV in microgravity conditions

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ABSTRACT

The influence of the air supply on the behavior of a diffusion flame representative of a fire is studied. The natural or forced ventilation of the reactive zone controls the chemical processes and acts on the flame properties. To have a better understanding of the phenomena involved in such a combustion, an experimental setup was designed and built to stabilize a buoyancy driven laminar diffusion flame over a flat burner. The flame behavior is characterized when the air supply of the combustion zone decreases to an under-ventilated environment. Conditions of a non shear flow were determined to limit vortex formation and to reach a diffusion controlled situation. For these purposes, tests were performed in microgravity to avoid any buoyancy effects leading to convection of air into the reaction zone. This reduced buoyancy environment allows diffusion transport to be developed without any flow perturbations.

Temperature (thermocouples) and velocity (Particle Image Velocimetry P.I.V.) fields are determined in normal and reduced gravity environments (parabolic flights). The PIV technique was successfully adapted to the study of such a reacting system despite many constraints: safety regulation., hostile environment, the short duration, and limited number of measurement tests.

The obtained results show a drastic modification of the behavior (location, size, color) and of the thermal properties of the flame when both buoyancy forces fall to zero and the flame becomes under-ventilated. The velocity flow measurements confirm the effects of natural convection on the flame structure inducing air supply at normal gravity, and attest that the reaction is stabilized in an non-shear zone. Consequently, the information on the flame behavior (temperature variation through the flame zone) can be used to model the involved combustion phenomena. The obtained information should be introduced into a fire safety analysis numerical code both for ground or spatial applications.