MICROGRAVITY SCIENCES AND PROCESSES (A2)
Fluid and Materials Sciences (2)

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OPPOSED-FLOW FLAME SPREAD IN CONSTRAINED SPACES UNDER NORMAL AND REDUCED GRAVITY CONDITIONS

Abstract

Flame spread over a solid material is of great interest to fire safety researchers. Most previous studies of flame spread have been performed in open areas. A flame spreading in a confined space, however, has practical importance for fire safety both in normal gravity and in a spacecraft. In the present study, opposed flow flame spread over thermally thin solid fuels was investigated in low-speed flow tunnels with finite heights. Such type of flame spread was addressed by combined use of normal gravity experiments, microgravity experiments, and computations. Primary variables included forced flow speed, oxygen concentration, tunnel height, and gravity. When the tunnel height h = 10–14 mm, the flame spread characteristics in normal gravity can effectively simulate those in microgravity. In a quiescent environment, steady flame spread can not occur; for flow speeds less than 15–20 cm/s, flame spread rates in microgravity can be essentially reproduced in tunnels of 12 mm and 14 mm height; for flow speeds greater than 15–20 cm/s, the microgravity flame spread rates can be simulated by flames spreading in a 10-mm-height tunnel. In narrow tunnels with height of 12 mm and 14 mm, the extinction boundary expressed by limiting oxygen concentration against characteristic relative velocity was found close to that obtained in microgravity, whereas the flammability boundary obtained in the 10-mm-height tunnel deviated from the microgravity case. The analysis showed that buoyant convection was suppressed to a high degree in narrow tunnels, consequently in which a simulated microgravity environment could be produced. The results also indicated some notable differences between observations under simulated and actual microgravity conditions, and these diversities may be attributed to the effects of residual buoyancy flow in the tunnel and heat loss to tunnel walls. The influence of a finite tunnel height on flame spread was discussed.