PLIF Visualisation and Qualitative Investigation on Plume Structure in Natural Convection

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Abstract

Planar Laser Induced Fluorescence visualisation (PLIF) of plume structures erupting from the species boundary layer formed over a semi-permeable membrane is conducted by having an unstable density difference across the semi-permeable membrane. The experiments were conducted at Prandtl number, Pr ~ 610, and over a range of Rayleigh number 3.1 ×1011 < RaH < 6.12 × 1010. The near membrane structures consist of line plumes erupting from the species boundary layer due to unstable density difference of having high concentration fluid (NaCl) in the top tank and low concentration fluid (NH4Cl) in the bottom tank. The pore size of the membrane allows advection across the membrane. The evolution of plumes from the species boundary layer was studied at different concentration differences, 2 < ΔC < 10. Three phases were observed in the evolution, viz, Pouring dominant phase, Transition phase and fully developed plume field. The planform of a fully developed plume structure consists of three zones: plume free region due to impingement of circulatory through flow across the membrane, aligned plume region where the plumes rising from the boundary layer are aligned in the direction of large-scale flow and instability driven plume region where the evolution of plumes isn't affected by shear. At constant RaH, the mean plume spacing in the shear-affected zone was found to be smaller than the instability-driven plume region.

Keywords

Convection across semipermeable membrane, plume structures, advection, circulation, Rayleigh number, Prandtl number.