Investigation of Atwood-ratio dependence of Richtmyer-Meshkov flows under reshock conditions using large-eddy simulation

M. Lombardini, D. J. Hill, D. I. Pullin & D. I. Meiron

Graduate Aerospace Laboratories, California Institute of Technology
Pasadena, California 91125, USA

We discuss the shock-driven turbulent mixing that occurs when a planar shock wave of moderate strength impacts a perturbed planar density interface and reshocks the interface after reflection off an end wall. A study of the influence of the relative molecular weights of the gases in the form of the initial Atwood ratio A is presented for the cases $A = \pm 0.21$, ± 0.67 and ± 0.87 that correspond to the realistic gas combinations air–CO_2, air–SF_6 and H_2–air. A canonical, three-dimensional numerical experiment using large-eddy simulation reproduces the interaction within a shocktube with an end wall, where the incident shock Mach number is ~ 1.5 and the initial interface perturbation has a fixed dominant wavelength, with a fixed amplitude-to-wavelength ratio ~ 0.1.

Diagnostics that include the perturbation amplitude and growth rate before and after reshock, and the relative interpenetration of fluids are reported. Additionally, the turbulent kinetic energy and dissipation histories are compared. We observe that for positive Atwood-ratio configurations, the reshock is followed by secondary interactions in the form of alternate expansion and compression waves traveling between the end wall and the mixing zone. These reverberations are shown to intensify turbulent kinetic energy and dissipation across the mixing zone. In contrast, negative Atwood-ratio configurations produce multiple secondary reshocks following the primary reshock, and their effect on the mixing region is less pronounced. As the magnitude of A is increased, the mixing zone tends to evolve less symmetrically.

Across the range of Atwood numbers investigated, measurements of the post-reshock growth rate, prior to the secondary wave interactions, do not agree well with predictions of existing analytic reshock models. Accordingly, we propose both an empirical formula and an impulsive model based on a diffuse-interface approach to describe the A-dependence of the post-reshock growth rate.