Shock-initiated combustion of a spherical density inhomogeneity.

Nicholas Haehn, Chris Weber, Jason Oakley, Mark Anderson & Riccardo Bonazza

University of Wisconsin-Madison,
Madison, WI, USA
bonazza@engr.wisc.edu
http://silver.neep.wisc.edu/∼shock/

Experimental results for an inert spherical density inhomogeneity accelerated by a strong incident shock wave ($M = 2.8$) are compared with a reactive mixture of similar density. When a heavy bubble is shock accelerated in a lighter ambient gas corresponding to a large Atwood number ($A > 0$), the shock wave at the exterior periphery of the bubble travels faster than the interior transmitted wave, resulting in shock-focusing at the downstream pole of the bubble. The shock wave convergence results in localized temperatures and pressures an order of magnitude higher than the conditions behind the shock wave. If the bubble is composed of a reactive mixture, these localized conditions allow for a controlled, point-source ignition for the combustible mixture within the bubble. The chemical and hydrodynamic coupling is investigated. The reactive mixture is composed of a stoichiometric mixture of H_2 and O_2 diluted with Xe (30%, 15% and 55% by molar fraction, respectively), corresponding to $A = 0.5$. For the purpose of comparison, experiments are performed on an inert mixture, where the Atwood number is matched using a combination of Xe and He (58% and 42% by molar fraction, respectively). The experiments are performed at the Wisconsin Shock Tube Laboratory in a 9 m vertical shock tube with a 25.4×25.4 cm^2 cross-section. A pneumatic injector is used to generate a 5 cm diameter soap bubble filled with the gas mixture. The injector retracts flushly into the side of the tube releasing the bubble into a state of free fall (Ranjan 2005, 2007). Diagnostics are performed using chemiluminescence of the OH^- molecule present during the combustion process and planar Mie scattering with a frequency doubled Nd:Yag. Due to an inherently weak signal, the chemiluminescence is captured with an intensified CCD camera, while the initial conditions are captured with a front-lit, high speed camera.

References

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