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Numerical Simulation of Liquid Oxygen Droplet Combustion in Hydrogen[1] JAMES HALL, MICHAEL ZODY, JON FRYDMAN, JAMES HERMANSON, University of Washington, FLORIAN MEYER, CHRISTIAN EIGENBROD, ZARM Center of Applied Space Technology and Microgravity, VOLKER WAGNER, WOLFGANG PAA, IPHT Leibniz Institute of Photonic Techology —
In liquid rocket propulsion oxygen normally enters the combustion chamber as a dispersed phase, while the hydrogen fuel rapidly evaporates into a continuous, vapor phase. The ignition and combustion of a single, liquid oxygen droplet in gaseous hydrogen surroundings is thus the essential, first step in the subsequent spray combustion process. The OpenFOAM platform is used to calculate species concentrations, temperatures, heat release, and reactant consumption for this system. The simulations suggest that ignition, subsequent to the initial diffusion of gaseous oxygen into hydrogen, initially results in the appearance of two flame zones. As quasi-steady combustion is approached, these two flames merge. The resulting stable, quasi-steady flame, combined with the conductive heat transfer from the flame to the droplet surface is used to predict the oxygen droplet-combustion lifetime. These numerical simulations are conducted in parallel with drop-tower tests at ZARM. The calculated lifetime of a 1-mm liquid oxygen droplet undergoing combustion in gaseous hydrogen at 1 bar pressure and an initial temperature of 100 K is comparable to that observed in the drop-tower tests.

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