Numerical Simulation of Blast Waves from Hydrogen–Air Detonations Triggered by Tank Failure

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Keywords: Numerical simulation, hydrogen tank, green aviation, safety in aviation, detonation, blast waves.

Abstract

The decarbonization of commercial aviation is accelerating interest in liquid hydrogen (LH2) as both an onboard fuel for future aircraft and an energy carrier to be stored and handled within airport infrastructures. In open environments, accidental releases from cryogenic tanks, either from parked aircraft or from ground-based storage and refueling systems, may generate unconfined hydrogen-air clouds whose ignition or detonation poses a major safety concern. Compared with conventional aviation fuels, LH2 presents a distinct hazard profile due to its cryogenic nature, rapid phase change upon release, high flammability, low ignition energy, and propensity to detonate. Moreover, LH2 can promote local oxygen enrichment through oxygen condensation and solidification, further increasing ignition sensitivity. In this work, blast wave generation and propagation in unconfined conditions are investigated using the one-dimensional spherical Euler equations with an ideal gas equation of state. Two modeling strategies are compared: an instantaneous detonation model based on the classical hot-bubble approximation, and a finite-rate model in which the hydrogen-air cloud detonates at finite propagation speed. The objective is to assess the ability of these approaches to reproduce the main features of blast evolution while retaining a computational cost suitable for preliminary hazard analyses. Numerical results are compared with experimental data from the literature. The study is a first attempt to provide a simplified but physically grounded framework for the assessment of blast effects associated with accidental LH2 releases in aviation-related unconfined scenarios.