

Experimental observation of deflagration to detonation transition: Shock- Finger Flame interaction in a rectangular channel

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1 Abstract

Hydrogen presents a key solution to boost industry decarbonization, however its widespread use poses major safety challenges due to its high flammability, low ignition energy, and broad flammability limits in the air. Ensuring the safe handling, storage, and transportation of hydrogen is important to avoid the risk of accidental leaks that can lead to violent explosion and rapid deflagration-to-detonation transitions (DDT) as illustrated by the Silver Eagle Refinery accident (2009).

The present paper investigates DDT in a rectangular channel with internal dimensions of 21mm x 45mm x 337mm. The experiments were conducted using premixed hydrogen-air under lean/rich conditions with different equivalence ratios, ambient temperature and low pressure (0.2 bar). High-speed side-view schlieren visualization was employed to capture the flame front evolution and shock interactions in real time. This optical diagnostic technique was complemented by pressure transducers distributed along the channel to provide quantitative measurements of the pressure rise, shock velocity and detonation propagation. The combination of visual and pressure data enabled detailed tracking of the flame acceleration, the formation of the shock-flame complex and the DDT phenomena. The facility successfully produced Chapman-Jouget (CJ) deflagrations which are critical in studying the DDT initiation phenomena.

Future work will extend this investigation to turbulent regimes to deepen our understanding of DDT under more complex flow conditions.

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