The Critical Transition Length From Chapman-Jouguet Deflagrations to Detonations

Mohamed Saif [1], M. Levin[2], A. Pekalski[3] and M.I.Radulescu[1]
1. Department of Mechanical Engineering
University of Ottawa, Canada K1N 6N5
2. Shell Exploration & Production Company (SEPCO)
3. Shell Global Solutions (UK)

Abstract

In the process of deflagration-to-detonation transition (DDT) in reactive gases contained in obstructed tubes, the flame typically accelerates to a Chapman-Jouguet deflagration speed, at which a steady state is usually observed. The present study addresses the subsequent acceleration to detonation. Laboratory-scale experiments were performed where Chapman-Jouguet deflagrations were established following the quenching of an incident detonation after its interaction with a perforated plate. The experiments were performed in methane, ethane, ethylene, acetylene and propane with oxygen as oxidizer. The subsequent acceleration was monitored via large scale time-resolved shadowgraphy. The mechanism of transition was found to be through the amplification of transverse waves and hot spot ignition. The critical distance for acceleration was determined in all mixtures and correlated with characteristic chemical kinetic time scales. These amplification times and length scales were found in good agreement with previous theoretical estimates for unconfined DDT based on the gradient mechanism for acceleration. The characteristic amplification lengths determined can thus serve to evaluate the propensity of detonation formation in partially obstructed or open geometries by the Dorofeev scaling. Dependencies of the amplification lengths on the kinetic times, as well as non-dimensional heat release, activation energies and induction-to-reaction time scale ratios are discussed based on a proposed model for shock induced ignition.

keywords
Deflagration to detonation transition (DDT), critical amplification length, mixture detonability

Correspondence to: msaif010@uottawa.ca