Experimental investigation of detonation behaviors in a non-uniform composition

Stéphane BOULAL[1,2], Pierre VIDAL[1], Ratiba ZITOUN[1]
[1]Institute P' (UPR 3346 CNRS), Fluid, Thermal and Combustion Sciences Department
ENSMA, F86961 Futuroscope Chasseneuil, France
[2]SAFRAN Snecma, Etablissement de Villaroche
77550 Moissy Cramayel, France

Keywords : Detonation, Non-uniform composition, Cell size, PDE, RDE

1 Abstract

Detonation-based propulsive systems, such as the Pulsed Detonation Engine (PDE) and the Rotating Detonation Engine (RDE) are being considered to replace conventional isobaric combustion engines because of their higher thermodynamic efficiency. However, before developing industrial detonation engines, a better control of detonation is required, and several fundamental aspects must be investigated separately. One of them is the effect of a non-uniform initial distribution of composition on the detonation existence and propagation. Indeed, the fuel and the oxidizer are injected separately in combustion chambers of detonation engines. Also, the simultaneous presence of fresh gas mixture and residues of detonation products in PDE and RDE chambers results in non-uniformities of composition. This experimental work aims at understanding the effect of a non-uniform composition on the dynamical behaviors of the detonation. An original experimental set-up was developed to generate a composition gradient parallel to the direction of detonation propagation in a 50 mm x 50 mm square section chamber. An upstream detonation tube with the same square section contains a uniform composition identical to that at the chamber entry so that the detonation is steady when entering the chamber with non-uniform composition. The initial distribution of composition in the chamber is determined by measuring the oxygen concentration with optical probes. The resulting detonation dynamics is analysed using pressure gauges, detonation velocity and cell size measurements, and high speed camera Schlieren visualizations. Depending on the initial distribution of composition, different dynamical behaviors are observed, such as multi cellular and helicoidal modes, shock-flame decoupling and quenching.

Correspondence to: stephane.boulal@ensma.fr