DETONATION INITIATION BY MEANS OF SUCCESSIVE TRIGGERING OF IGNITION FROM AN EXTERNAL SOURCE

Frolov S.M.[1], Basevich V.Ya.[1], and Aksenov V.S.[2]
[1] N.N. Semenov Institute of Chemical Physics, Moscow, RUSSIA
[2] Moscow Institute of Physical Engineering (MIFI), Moscow, RUSSIA
e-mail: smfrol@center.chph.ras.ru

One of the most challenging problems encountered in the development of advanced propulsion systems (e.g., pulse detonation engines) is detonation initiation in fuel-air mixtures at distances that are feasible for propulsion applications. As is well known, detonation occurs via a transient stage of strong coupling between the shock wave and the shock-induced reaction in the explosive medium. This paper suggests a promising technique for detonation initiation that is based on the necessity of the strong coupling between a shock wave and energy deposition. Fundamentally, no matter how the energy is deposited into the post-shock flow: either spontaneously, due to shock-induced chemical reactions, or by means of inducing chemical reactions with an external energy source. In the former approach, due to a highly activated nature of exothermic chemical reactions in fuel-air mixtures, shock waves of high amplitudes and durations are required to ensure the coupling. Such shock waves can be obtained by means of exploding high-explosive charges with a mass exceeding 20-30 g. The latter approach implies the use of an external energy source to artificially induce exothermic reactions behind a relatively weak shock wave in order to stimulate the strong coupling. Clearly, in this case the external energy source should be distributed rather than concentrated and should provide continuous coupling of energy deposition with a propagating shock wave. The idea of the proposed technique is to initiate a weak shock wave and to accelerate it by in-phase triggering of distributed external energy sources (spark igniters) in the course of shock wave propagation along the tube.

To substantiate the approach, the experimental study was performed with gas-phase and two-phase reactive mixtures.

In the experiments with gas-phase mixtures, a weak shock wave was accelerated in the mixture by means of in-phase triggering of spark igniters (up to 7) in the course of shock wave propagation along the tube (51 mm in diameter). Detonation-like regimes have been obtained at a distance of 0.6-0.8 m in stoichiometric C_3H_8 - (O2+3N_2) and C_3H_8 - air mixtures under normal conditions.

In the experiments with *n*-hexane and *n*-heptane sprays the following findings were obtained: (1) there exist resonant conditions for successive triggering of two igniters that have to be met in order to initiate detonation; (2) the minimal total detonation initiation energy by successively triggered igniters is lower than that required for direct detonation initiation by a single igniter; (3) the detonation peninsula at the “initiation energy vs. triggering time delay” plane is very narrow that indicates the necessity of careful synchronization of successive discharge triggering.