VISUALIZATION RESULTS OF HYDROGEN IGNITION IN SHOCK TUBES

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ABSTRACT: The understanding of hydrogen combustion has an essential significance for the development of prospective gas turbines and engines. In this lecture we consider the results of optical investigations of an intriguing phenomenon of hydrogenous mixture self-ignition behind reflected shock wave. Brief historical review of the traditional shock-tube optical studies will serve as a basis for detailed analysis of recent investigations. We represent an overview of the results achieved in the frame of a long-term collaboration between Heterogeneous Combustion Laboratory of Semenov Institute of Chemical Physics (Moscow) and Shock Wave Laboratory RWTH Aachen University. This scientific program was initiated in 1997 by Professor Boris Gelfand (1941-2010) and Professor Hans Grönig. The experiments were performed in a helium-driven shock tube of 11 m in length and 54 x 54 mm^2 in cross-section. Among other directions the performed investigations included visualization of explosive regimes initiated in lean H_2-air mixtures by shock focusing. Figures 1a,b,c illustrate different modes revealed in experiments with 8% H_2 in air mixture: a) mild ignition; b) transient detonation initiation; c) direct initiation of detonation.

Recently the same experimental setup was used for study of the low-temperature self-ignition of turbulized H_2-air mixtures under over-tailored conditions. This technique enables to extend observation time up to 30 ms. Figure 1d represents spot ignition and subsequent flame propagation in 15% H_2 in air mixture at pressure of 11 bar and temperature of 750 K. Visualization results of hydrogen ignition in shock tubes were used for verification of reaction mechanism of hydrogen oxidation.

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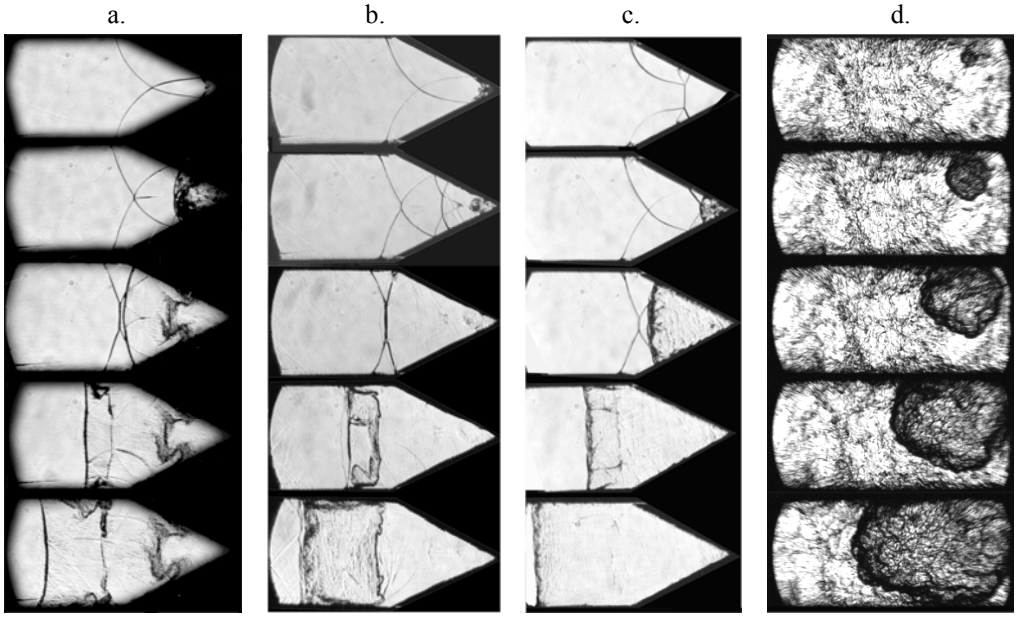

Fig. 1 Shadow images of different ignition modes in lean hydrogen-air mixtures under shock focusing (a,b,c) and over-tailored (d) conditions. Time between frames 40 μs (a,b,c) and 1 ms (d).