DEFLAGRATION-TO-DETONATION TRANSITION IN AIR MIXTURES OF ETHYLENE–HYDROGEN FUEL

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Abstract: The experimental method for evaluating the detonability of fuel–air mixtures (FAMs) based on measuring the run-up distance and time of deflagration-to-detonation transition (DDT) in a pulsed detonation tube (DT) was used to study the DDT in FAMs based on the blended ethylene–hydrogen fuel with a volume fraction of hydrogen ranging from 0 to 1 at the same thermodynamic and gasdynamic conditions. Based on the available data on combustion and self-ignition of such a blended fuel, it was expected that with an increase in the volume fraction of hydrogen, the DDT run-up distance and time should monotonically decrease and the corresponding dependences should be close to linear. Contrary to expectations, the obtained dependences turned out to be nonlinear. The analysis of the results suggests that the observed dependences are a manifestation of the physicochemical properties of the FAMs under study. Changes in the design of the flame acceleration section in the DT do not affect much the nature of the obtained dependences: they remain nonlinear.

Keywords: ethylene–hydrogen fuel; fuel–air mixture; detonability; pulsed detonation tube; deflagration-to-detonation transition

Figure Captions

Figure 1 Schematics of the detonation tube of three configurations: K1 (*a*), K2 (*b*) and K3 (*c*) with the indication of measuring sections; ∗ is the location of the spark plug. Dimensions are in millimeters

Figure 2 Detonation velocity – distance plots for the development of DDT process in 5 successive shots in stoichiometric air mixtures of ethylene–hydrogen fuel with $x_{H_2} = 0$ (*a*), 0.2 (*b*), 0.4 (*c*), 0.6 (*d*), 0.8 (*e*), and 1 (*f*); tube of configuration K1

Figure 3 Detonation velocity – distance plots for the development of DDT process in 5 successive shots in stoichiometric air mixtures of ethylene–hydrogen fuel with $x_{H_2} = 0$ (*a*), 0.2 (*b*), 0.4 (*c*), 0.6 (*d*), 0.8 (*e*), and 1 (*f*); tube of configuration K2

Figure 4 Detonation velocity – distance plots for the development of DDT process in 5 successive shots in stoichiometric air mixtures of ethylene–hydrogen fuel with $x_{H_2} = 0$ (*a*), 0.2 (*b*), 0.4 (*c*), 0.6 (*d*), 0.8 (*e*), and 1 (*f*); tube of configuration K3

Figure 5 Time–distance diagrams for the development of DDT process in the stoichiometric air mixture of ethylene–hydrogen fuel with $x_{H_2} = 0.4$ in 5 successive shots in the tube of configurations K3 (*a*) and K2 (*b*)

Figure 6 Primary records of pressure sensors (solid curves) and ionization probes (dotted curves) in measuring sections 7 to 16 in one of 5 shots for the stoichiometric air mixture of ethylene–hydrogen fuel with $x_{H_2} = 0.4$ in a tube of configuration K2

Figure 7 Measured DDT run-up distance (*a*) and time (*b*) as functions of hydrogen volume fraction x_{H_2} in the stoichiometric air mixtures of ethylene–hydrogen fuel in tubes of configurations K1 (*1*), K2 (*2*), and K3 (*3*)

Figure 8 Measured DDT run-up distance L_{DDT} (*a*) and time τ_{DDT} (*b*) as functions of fuel-to-air equivalence ratio Φ in the air mixtures of ethylene–hydrogen fuel with different values of x_{H_2} in the tube of configuration K1: *1* — 1.0; *2* — 0.9; *3* — 0.8; *4* — 0.7; and *5* — 0.0

Figure 9 Calculated dependences of the self-ignition delays of stoichiometric air mixtures of ethylene–hydrogen fuel on temperature, pressure, and volume fraction of hydrogen: *1* — $x_{H_2} = 0$; *2* — 0.2; *3* — 0.4; and *4* — $x_{H_2} = 0.6$ [21]. The shaded area approximately corresponds to the states of fuel mixture at DDT

Acknowledgments

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