ON HEAT FLUX MEASUREMENTS OF LOCALLY HETEROGENEOUS SELF-IGNITION OF COMBUSTIBLE MIXTURES BEHIND A SHOCK WAVE

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Abstract: An experimental study was conducted to register the heat flux from ignition of shock-heated gaseous mixtures using a thermoelectric detector. The efficiency of the method was demonstrated using self-ignition of propane–air, propane– and propylene–oxygen–argon mixtures behind a reflected shock wave. Time dependences of signals from a piezoelectric pressure sensor, a thermoelectric detector, and optical channels configured to record the radiation of electronically excited radicals were analyzed. The zones of locally heterogeneous self-ignition and combustion of gas mixtures were shown. The possibility of measuring short ignition delay times (microseconds and less) was demonstrated.

Keywords: heat flux; combustible mixture; ignition delay time; propane; propylene; thermoelectric detector

DOI: 10.30826/CE25180206 **EDN:** LGYFAX

Figure Captions

Figure 1 Schematic of shock tube end-wall section with a projection of the receiving apertures of the devices used: spectral measurement and optical recording devices; TD — thermoelectric detector; DD — pressure sensor; OF — optical filter; OS — optical system; and PMT — photomultiplier tube. Dimensions are in millimeters

Figure 2 Readings of DD and TD in experiments #1 (black curves) and #2 (grey curves) [12]: $\varphi = 0.5$ (2.1% C_3H_8 / 20.56% O_2 / 77.34% N_2); temperature of the propane–air mixture behind the reflected shock wave is 1620 and 1644 K, respectively; shock wave speed is 1276 and 1289 m/s, respectively; initial pressure in the low pressure chamber (LPC) is 200 mbar; and 0 μs is the arrival of the shock wave at the end wall

Figure 3 Time histories of pressure (DD), heat flux (TD), and intensity of OH^* radical emission (OS and OF) recorded during self-ignition of stoichiometric ($\varphi = 1.0$, 4.2% C_3H_8 / 20.12% O_2 / 75.68% N_2) propane–air mixture [12]. Temperature behind the reflected shock wave is 1670 K; initial pressure in the LPC is 170 mbar; shock wave velocity is 1302 m/s; and 0 μs is the arrival of the shock wave at the end-wall

Figure 4 Readings indicating self-ignition of the propane–oxygen–argon mixture ($\varphi = 2.5$, 2% C_3H_8 / 4% O_2 / 94% Ar) behind the incident shock wave: temperature behind the reflected shock wave is 7045 K; initial pressure in the LPC is 200 mbar; shock wave velocity is 1486 m/s; and 0 μs is the arrival of the shock wave at the end-wall

Figure 5 Nonstationary self-ignition of a propylene–oxygen–argon mixture ($\varphi = 1.9$, 1.5% C_3H_6 / 3.5% O_2 / 95% Ar): temperature behind the reflected shock wave is 2457 K; pressure in the LPC is 360 mbar; shock wave Mach number is $M = 3.1$; and 0 μs is the arrival of the shock wave at the end wall

Acknowledgments

The work was implemented within the state assignment of the Lomonosov State University and the Ministry of Science and Higher Education of the Russian Federation No. 124012500440-9 and within the state assignment of the National Research Center "Kurchatov Institute."

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Received November 29 2024
After revision February 10, 2025
Accepted February 18, 2025

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