LOCAL VELOCITIES OF HOT-SPOT COMBUSTION FRONT IN HMX

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Abstract: The mechanism of HMX combustion at pressures of 0.05–5.0 MPa is investigated. It is shown that HMX burns in the focal (hot-spot) mode. In the article "HMX combustion mechanism" by V. N. Marshakov, V. G. Krupkin, and S. A. Rashkovsky (2020. Russ. J. Phys. Chem. B 14(6):934–939. doi: 10.1134/S1990793120060111), the scale of inhomogeneity of the combustion surface — the characteristic size of hot spots is determined. The dependence of the size of the hot spots on the average burning rate of the sample is obtained. In the present article, the temperature distributions in the combustion wave obtained using thermocouples are analyzed. The local burning rates are obtained from the analysis of temperature distributions in the condensed phase (close to the Mikchelson distribution). It is shown that the scatter of the burning rate values is explained by the registration of the velocity at different points of the transverse wave front. The values of the local burning rates exceeding the average burning rate are caused by the elevated initial temperature of the sample ahead of the flame front and the smaller values are explained by the curvature of the flame front and by the buckling mode of combustion.

Keywords: HMX; multidimensional combustion front; mechanism of hot-spot combustion; transverse waves; local burning rate

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Figure Captions

Figure 1 Dependence of the burning rate on the pressure: *1* — our data, *2* — [7, 9, 11], *3.1–3.4* — [5], *4* — [12], *5* — [4], and *6* — [1]

Figure 2 Temperature profiles of the HMX combustion wave at a pressure of 0.05–4 MPa (1–3): (*a*) three Π-shaped thermocouples; and (*b*) the same profiles in the condensed phase in semilogarithmic coordinates with the release of straight-line segments to determine the local burning rate (*1* — $\ln T_1$, 0,026–0,04 cm/s; *2* — $\ln T_2$, 0,023 cm/s; and *3* — $\ln T_3$, 0,024–0,033–0,022 cm/s)

Figure 3 Temperature profiles of the HMX combustion wave: (*a*) $p = 0.075$ MPa, three Π-shaped thermocouples; and (*b*) $p = 0.1$ MPa, Λ-shaped thermocouple

Figure 4 Temperature profiles of the HMX combustion wave at $p = 0.5$ MPa: (*a*) four Π-shaped thermocouples, and (*b*) the same profiles in the condensed phase in semilogarithmic coordinates

Figure 5 Temperature profiles of the HMX combustion wave at $p = 1.1$ MPa: (*a*) three Π-shaped thermocouples; and (*b*) $p = 2.0$ MPa, four Λ-shaped thermocouples

Figure 6 Temperature profiles of the HMX combustion wave at $p = 4.0$ MPa: (*a*) three Π-shaped thermocouples; and (*b*) the same profiles in the condensed phase in semilogarithmic coordinates, $T_s = 490$ °C (*1* — $\ln T_1$, 0,89–0,64 cm/s; *2* — $\ln T_2$, 0,89–0,45 cm/s; and *3* — $\ln T_3$, 0,89–0,36 cm/s)

Figure 7 The scatter of the values of the local burning rate at different pressures: *1* — 0.05 and 0.075 MPa; *2* — 0.1 MPa; *3* — 0.1 MPa [12]; *4* — 0.5 MPa; *5* — 1.0 [1] and 1.1 MPa; *6* — 2.0 and 2.3 MPa; *7* — 4.0 MPa [1]; vertical line segments — the spread of U_n values in other experiments; A — $U_{\text{av}} = 2.39p^{0.81}$; B — $U = U_{\text{av}}/1.65$; and C — $U = U_{\text{av}} \cdot 1.65$

Figure 8 Burning rate vs. pressure and initial temperature: *1* — our data, $T_0 = 20$ °C; *2* — $T_0 = 20$ °C [9]; *3* — $T_0 = 100$ °C [1]; *4* — $T_0 = 100$ °C [9]; A — $U_{\text{av}} = 2.39p^{0.81}$; and B — approximation according to data *3* and *4*

Table Caption

The value of the local burning rate U_n (mm/s) and pressure p (MPa)

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