INFLUENCE OF AIR SUSPENSION FLOW PARAMETERS ON FLAME PROPAGATION VELOCITY AND LIMITS

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Abstract: The article presents experimental data on how the initial parameters of an aluminum particle–air suspension flow — specifically, the air-to-fuel equivalence ratio (ER) (α), Sauter mean diameter (d_{32}), initial temperature (T_0), and turbulence intensity (ε_0) — influence the visible flame speed and propagation limits. The behavior of the flame speed as a function of the ER, $u_f(\alpha)$, was established for the air suspension flows of ASD-1 and ASD-4 aluminum powders. For both grades, in the rich region on the dependence graph, there is a maximum at $\alpha \approx 0.2$. For ASD-1 particles with $d_{32} = 17.4$ μm, which burn in the diffusion mode, the flame speed decreases monotonically with an increase in the ER. For ASD-4 particles with $d_{32} = 7.4$ μm, which burn in the kinetic mode, the $u_f(\alpha)$ dependence has a second maximum near the stoichiometry. The dependence of the visible flame velocity on the ER obtained in this work in a wide range of $\alpha = 0.1$–3.0 provides a correct interpretation of the results of studies both in flows and in quiescent air suspensions of aluminum particles.

Keywords: visible speed; limits; propagation; flame; composition; air suspension; mode; combustion; air-to-fuel equivalence ratio

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Figure Captions

Figure 1 Schematic diagram of the experimental setup: *1* — ejector nozzle; *2* — powder intake tube; *3* — hopper; *4* — ejector receiving chamber; *5* — ejector mixing chamber; *6* — combustion chamber; *7* — perforated disk; *8* — spark plug; and *9* and *10* — electric valves

Figure 2 Influence of ER and initial temperature (*1* — $T_0 = 293$ K; *2* — 423; and *3* — $T_0 = 523$ K) on the flame speed and propagation limits; ASD-1 powder ($d_{32} = 17.4$ μm); $D = 0.08$ m; and $P_0 = 0.1$ MPa

Figure 3 Influence of turbulence intensity and scale on flame speed and propagation limits, ASD-1 powder ($d_{32} = 17.4$ μm); $D = 0.06$ m: *1* — $l_0 = 0.01$ mm and $\varepsilon_0 = 12\%$; and *2* — $l_0 = 0.07$ mm and $\varepsilon_0 = 22\%$

Figure 4 Influence of the fractional composition of a polydisperse aluminum–air suspension (*1* — 5 μm — 30%, 25 μm — 35%, and 75 μm — 35%; and *2* — 5 μm — 15%, 25 μm — 40%, and 75 μm — 45%) on the flame speed and propagation limits, $D = 0.08$ m, $P_0 = 0.1$ MPa, and $T_0 = 293$ K

Figure 5 Influence of ER on the flame speed and propagation limits, ASD-4 powder ($d_{32} = 7.4$ μm); $D = 0.04$–0.08; $P_0 = 0.1$ MPa; $\varepsilon_0 = 5\%$–22%; and $T_0 = 293$–523 K

Figure 6 Flame front in the flow of airborne suspension of aluminum particles ASD-4: $d_{32} = 7.4$ μm; $D = 0.042$ m; $u_0 = 50$ m/s; $\alpha = 0.1$; $T_0 = 293$ K; and $P_0 = 0.1$ MPa

Figure 7 The influence of ER on the flame speed and propagation limits, ASD-1 powder: $d_{32} = 17.4$ μm; $D = 0.04$–0.08 m; $P_0 = 0.1$ MPa; $\varepsilon_0 = 5\%$–22%; and $T_0 = 293$ K

Figure 8 Flame front in the flow of airborne suspension of aluminum particles ASD-1 ($d_{32} = 17.4$ μm); $D = 0.042$ m; $u_0 = 50$ m/s; $\alpha = 0.1$; $T_0 = 293$ K; and $P_0 = 0.1$ MPa

Figure 9 Flame propagation velocity as a function of concentration: *1* — Valimet H5 powder ($d_{32} = 5$ μm), experiment [15]; *2* — aluminum particle diameter $d_{32} = 6$ μm, experiment [2]; and *3* — stoichiometric composition

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