MEASUREMENT OF THE MELTING AND COMBUSTION CHARACTERISTICS OF A PARAFFIN SAMPLE IN A HOT AIR FLOW

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Abstract: The article presents the results of experiments involving blowing hot air onto paraffin samples which causes the material to melt, form a thin melt layer, disperse, and ignite spontaneously. Measurements of longitudinal forces arising during the outflow of combustion products from the combustion chamber are considered. The results of a series of experiments are presented over a wide range of air flow rates, chamber inlet temperatures, and pressures, including ignition delay time, maximum chamber pressure, and developed thrust. Specific impulse estimates are presented, using paraffin as an example, demonstrating the potential of using low-melting propellants in hybrid rocket engines.

Keywords: melting; self-ignition; paraffin; hybrid rocket engine; experiments

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Figure Captions

Figure 1 Diagram of the experimental setup: *1* — working chamber with a replaceable calibrated nozzle; *2* — cowper-type hot-blast heater; *3* — air receiver with compressor; *4* — regulating (control) valve; *5* — shutoff valve; *6* — pulsation-free air supply system; *7* — measuring instrumentation; *8* — high-speed video camera; *9* — computer; *10* — exhaust (fume extraction) system; F — thrust sensor; P — static pressure sensor; and T — temperature sensor

Figure 2 The working chamber with the installed sample

Figure 3 Comparison of experimental (solid lines) and theoretical (dashed lines) $p(t)$ dependencies during the setup's transition to steady state: (*a*) experiments without a sample (*1*) and with a sample without ignition (*2*); and (*b*) experiments with ignition of the sample (*3–5*)

Figure 4 Diagrams of pressure in the working chamber (*a*) and measured hollow thrust (*b*, grey line) for the experiment without a sample ($d_{\text{cr}} = 15$ mm). The black line on (*b*) is the calculation according to Eq. (5), considering the average coefficient φ_0 (Fig. 5)

Figure 5 The ratio of measured and theoretical void thrust (grey line) for the idle experiment shown in Fig. 4. The horizontal straight line is the average value of φ_0 of the $\varphi(t)$ function

Figure 6 Quasi-stady operation of the setup in combustion experiments

Figure 7 Characteristics of paraffin combustion in a working chamber with a sound nozzle with a diameter of $d_{\text{cr}} = 15$ mm: (*a*) $G_a = 0.14$ kg/s and $T_{\text{in}} = 837$ K; and (*b*) $G_a = 0.153$ kg/s and $T_{\text{in}} = 805$ K. The pressure graphs show the time dependencies of the pressure in a chamber without a sample under similar conditions (see Fig. 4)

Table Captions

Table 1 Characteristics of the installed sensors

Table 2 Initial parameters and results of combustion experiments

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