THERMAL STRUCTURE OF THE GUNPOWDER BURNING WAVE AT ELEVATED PRESSURES

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Abstract: The thermal structure of the combustion wave in a double-base propellant is studied at elevated pressures up to 1000 atm using a thermocouple technique (3-micron thick tungsten-rhenium thermocouples). The experiments are carried out in a two-chamber installation which is a main reactive combustion chamber with a volume of 330 cm^3 equipped with a replaceable conical nozzle and communicating with it additional chamber of a smaller volume of 45 cm^3 in which the sample under study with embedded thermocouples is placed. The operating pressure in the installation is achieved by burning a powder cartridge in the main chamber and the pressure level varies from experiment to experiment by using a set of nozzles with different cross sections. The paper analyzes and substantiates the applicability of the thermocouple technique and the temperature profiles when a combustion wave passes through the sample at constant pressures of 310, 480, 605, 730, and 930 atm are obtained. Corrections of the temperature profile in the gas phase are made taking into account the amendments associated, firstly, with a decrease in temperature in the readings of the thermocouple due to its radiation into the environment and, secondly, with a decrease in readings due to the inertia of the thermocouple in the case of its heat exchange with a medium having high values of the temperature gradient. It is shown that at some points of the profile, the corrections can reach 500 °C in total. The thermal effects and characteristic sizes of the reaction zones in the condensed and gaseous phases are determined. The burning rates are measured and the heat effects and characteristic sizes of the reaction zones in the condensed and gas phases are calculated.

Keywords: combustion; double-based propellant; burning wave; thermocouple; temperature; pressure; thermal effects

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Figure Captions

Figure 1 Schematic of experimental installation: *1* — main combustion chamber; *2* — satellite; *3* — gunpowder charge; *4* — block with thermocouples; *5* — igniter; *6* — saddle; *7* — igniter of gunpowder sample *8*; *9* — thermocouple connected to input of Topaz amplifier *11*; *10* — pressure sensor DD-20 connected to the input of induction converter IVP-2 *13*; and *12* — beam oscilloscope H-115 (to avoid cluttering up the figure, the second thermocouple and its connection to the oscilloscope are not shown)

Figure 2 Dependence of the burning rate of propellant N on pressure: *1* — authors' data; *2* — dependence (1); *3* — data [1, 2]; *4* — dependencies $u = 0.075 + 0,01p^{0.95}$ [cm/s] (at $10 < p < 50$ atm) and $u = 0.39 + 0.006p$ [cm/s] (at $50 < p < 950$ atm); and *5* — data [3]

Figure 3 Burning wave profiles in propellant N at $p = 310$ (*a*), 480 (*b*), 695 (*c*), 730 (*d*), and 930 atm (*e*): *1* — initial profile; and *2* — corrected profile

Table Captions

Table 1 Parameters of burning zones in propellant N

Table 2 Thermal structures of the burning wave at $p = 310$, 480, 605, 730, and 930 atm

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