LASER INITIATION OF ENERGETIC MATERIALS

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Abstract: The purpose of the work is a brief overview of theoretical and experimental studies of the mechanism of laser initiation of energy-intensive materials performed in recent years in the Laboratory of Physics of Solid Propellant Combustion at the N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences. The theoretical analysis is carried out within the framework of the nonresonant (thermal) effect of light radiation on energy-intensive material. Special attention is paid to the specific features of the initiation of metallized explosives by a short laser pulse of low energy. The physical and chemical factors in the process of laser initiation, including the influence of metal inclusions, are analyzed. The influence of the diameter of the light beam, the size, and nature of optical inhomogeneities is considered. The influence of these factors on the laser-induced initiation is demonstrated depending on the duration of the laser pulse and density of the light flux.

Keywords: energetic materials; laser initiation; metal inclusions; optical inhomogeneities; light flux density

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Figure Captions

Figure 1 Schematic of laser beam delivery to the propellant charge in the barrell of the 155-millimeter howitzer at laser initiation. Neodymium laser (Nd:YAG), Breech Mounted Laser Igniter

Figure 2 Inert particle temperature variation at laser irradiation in adiabatic (solid curves) and nonadiabatic (dashed curves) conditions: *1* — particle radius $r_p = 10^{-3}$ mm; and *2* — $r_p = 10^{-2}$ mm

Figure 3 Enveloping curve $T_m(t)$ for family of curves $T_p(t)$ for different particle radii in nonadiabatic conditions: *1* — $r_p = 10^{-3}$ mm; and *2* — $t_p = 10^{-2}$ mm

Figure 4 Critical dimension of metal inclusion and reaction zone length as a function of the type of energetic material and its temperature: *1* — ballistic powder N, $l = 10^{-2}$ cm, $\lg(\rho\lambda q k_0) = 22.56$, $E = 201$ kJ/mol, and $\lambda = 2.35 \cdot 10^{-3}$ W/(cm·K); *2* — HMX, $l = 10^{-2}$ cm, $\lg(\rho\lambda q k_0) = 23.26$, $E = 220$ kJ/mol, and $\lambda = 2.90 \cdot 10^{-3}$ W/(cm·K); *3* — RDX, $l = 10^{-3}$ cm, $\lg(\rho\lambda q k_0) = 19.01$, $E = 172$ kJ/mol, and $\lambda = 1.67 \cdot 10^{-3}$ W/(cm·K); *4* — lead azide, $l = 10^{-5}$ cm, $\lg(\rho\lambda q k_0) = 16.83$, $E = 152$ kJ/mol, and $\lambda = 1.76 \cdot 10^{-3}$ W/(cm·K); and *5* — nitrocellulose, $l = 5 \cdot 10^{-4}$ cm, $\lg(\rho\lambda q k_0) = 22.90$, $E = 210$ kJ/mol, and $\lambda = 2.35 \cdot 10^{-3}$ W/(cm·K)

Figure 5 The influence of the type of energetic material on the dependence of the critical density of ignition energy E^* on the initial temperature T_0 at a radiation flux of $J = 200$ W/cm^2 and $h \approx 0$ for XMX (*1*), RDX (*2*), and ballistic powder N (*3*)

Figure 6 Schematic of a typical experimental assembly [17]: *1* — glass window; *2* — casing; *3* — energetic material; *4* — plug; and *5* — light beam

Figure 7 Photographs of pressed cylindrical samples prepared for testing: top — nickel II (hydrazine) perchlorate; and bottom — Bis (copper carbohydrazite II) perchlorate

Figure 8 Photograph of the open assembly for inserting a sample of energetic material

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