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INFLUENCE OF CHARACTERISTIC DIMENSIONS OF NTO AND HNS IN CUBIC SHAPE ON THE CRITICAL TEMPERATURE OF A THERMAL EXPLOSION*

A. V. KHANEFT[1,2], E. S. GALAKTIONOVA[1]

[1]*Kemerovo State University, Kemerovo, Russia*
[2]*National Research Tomsk Polytechnic University, Tomsk, Russia*

The paper analyzes the experimental data provided in [1] on the thermal explosion of low-sensitive explosives (EM) in the form of a cube: NTO and HNS. The ignition criterion of EM is generally defined by the expression:

$$\varphi(\mathrm{Bi})\,\delta_{cu}^{*} = l^2\,\frac{\rho QZ}{\lambda}\,\frac{E}{RT_s^{*2}}\exp\left(-\frac{E}{RT_s^{*}}\right), \qquad (1)$$

where T_s^* – is the surface temperature of the EM; l – характерный размер куба. Critical number for the cube $\delta_{cu}^{*} = 3\pi^2/\mathrm{e} = 2{,}72$ [2]. Function $\varphi(\mathrm{Bi})$ can be calculated in the following way [3]:

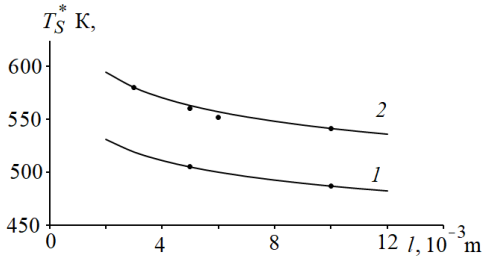
$$\varphi(\mathrm{Bi}) = \frac{\mathrm{Bi}}{2}\left(\sqrt{\mathrm{Bi}^2+4}-\mathrm{Bi}\right)\exp\left(\frac{\sqrt{\mathrm{Bi}^2+4}-\mathrm{Bi}-2}{\mathrm{Bi}}\right). \qquad (2)$$

From (1) we have an equation for determining the activation energy of the stationary rate of exothermic decomposition of EM:

$$E = 2R\,\frac{T_{S1}^{*}T_{S2}^{*}}{T_{S1}^{*}-T_{S2}^{*}}\left\{\ln\left(\frac{l_2T_{S1}^{*}}{l_1T_{S2}^{*}}\right)+\frac{1}{2}\ln\left[\frac{\varphi(\mathrm{Bi}_1)}{\varphi(\mathrm{Bi}_2)}\right]\right\}, \qquad (3)$$

where T_{S1}^{*}, T_{S2}^{*} – critical ignition temperatures of EM at characteristic cube sizes l_1 and l_2 accordingly. At $\mathrm{Bi} >> 1$, the second term in (3) ~ 0. Results of calculations of activation energies and parameter ratios $\rho QZ/\lambda$ for NTO and HNS are shown in the table.

EM	NTO	HNS
E, kJ/mol	165,621	170,386
$\rho QZ/\lambda$, K/m^2	$18{,}847\times10^{22}$	$1{,}099\times10^{22}$



Dependence of the critical ignition temperature of cube-shaped explosives on its characteristic size: 1 – NTO, 2 – HNS (points – experiment [1], lines – calculation)

The critical ignition temperatures of EM were calculated using equation (1). As can be seen from the figure, the calculation results are in good agreement with the experiment [1]. In addition, we solved the heat conduction equation with Arrhenius nonlinearity. The calculation results agree with the critical ignition temperatures of NTO and HNS.

REFERENCES

[1] Krause G. Volume-Dependent Self-Ignition Temperatures for Explosive Materials. Propellants, Explosves, Pyrotechnics. Vol. 37, 107-115, 2012.
[2] Khaneft A. Determination of the Critical Temperature of Self-Ignition of Explosives from the Stability Analysis of the Thermal Conductivity Equation. Propellants, Explosives, Pyrotechnics. Vol. 46, No 3. P. 368-377, 2021.
[3] Barzykin V. V., Merzhanov A. G. The boundary objective in the theory of a thermal explosion. Dokl. Akad. Nauk SSSR. Vol. 120, No 6, 1271-1273, 1958.

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