FEATURES OF LASER IGNITION OF HEM CONTAINING MIXTURES OF AL AND B*

A.G. KOROTKIKH[1], I.V. SOROKIN[1]

[1] Tomsk Polytechnic University, Tomsk, Russia
[2] Tomsk State University, Tomsk, Russia

The use of metal powder as a fuel in high-energy materials (HEMs) for the propulsion is the most energy efficient method allows to increase of HEMs combustion and ignition characteristics [1-3] and specific impulse [3]. In this study, we investigated the HEMs samples based on a mechanical mixture of powders such as aluminium with different dispersions and amorphous boron to determine the ignitability and ignition delay time as a function of the heat flux density.

We used three HEM samples to determine the ignition characteristics. The first HEM sample contained 64.6 wt.% ammonium perchlorate, 19.7 wt.% energetic binder and 15.7 wt.% amorphous boron as a metal fuel. In the other HEM samples, boron was partially substituted by aluminium powders with particle size 0.18 μm (Alex) or 10.8 μm (ASD-4).

The ignition process was studied via the setup for radiant heating based on a CO_2 laser with 10.6 μm wavelength and 200 W powers. The ignition delay times of HEM compositions t_{ign} were measured in the range of the heat flux density q = 60–220 W/cm^2.

Figure 1 shows the dependence of the ignition delay time for the HEM samples on the mean radiative heat flux density. A partial replacement of boron with aluminum Alex leads to a decrease in the ignition delay time of the HEM sample by 1.03–1.56 times in the range of heat flux density of 90–200 W/cm^2. The use of aluminum powder ASD-4 makes it possible to increase the ignition delay time of the HEM sample by 1.20–1.28 times in comparison with the boron-based composition.

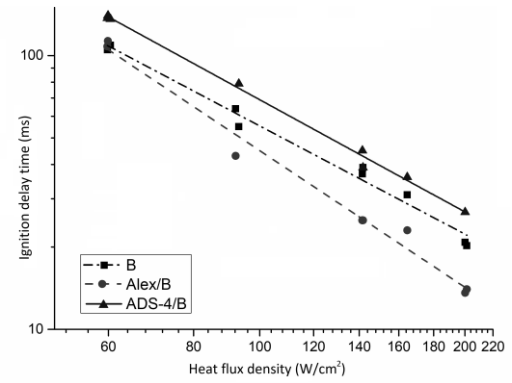

Fig.1. The ignition delay time of the HEM samples vs. the heat flux density.

The difference of the ignition delay time for the HEM samples heated by a radiant flux depends on the oxidation rate and the heat released from the chemical reaction for the metal fuels under study. Aluminum microparticles are difficult to ignite and react slowly [4] unlike nanosized aluminum powder [5]. Therefore, the ignition delay time for compositions with Alex/B takes smaller values than compositions with ASD-4/B.

REFERENCES

[1] A.G. Korotkikh, O.G. Glotov, V.A. Arkhipov, V.E. Zarko, A.B. Kiskin, "Effect of iron and boron ultrafine powders on combustion of aluminized solid propellants," Combust. Flame, vol. 178, pp. 195–204, 2017.

[2] Sh.L. Huseynov and S.G. Fedorov, Nanopowders of aluminum, boron, aluminum borides and silicon in high-energy materials, Moscow: Torus Press, 2015.

[3] A.G. Korotkikh, V.A. Arkhipov, O.G. Glotov, I.V Sorokin, "Effect of ultrafine powders of metals on the combustion characteristics," Chem. Phys. Mesoscopy, vol. 18, no. 2, pp. 173-179, 2018.

[4] W.Q. Pang, F.Q. Zhao, L.T. DeLuca, C. Kappenstein, H.X. Xu, X.Z. Fan, "Effects of nano-sized Al on the combustion performance of fuel rich solid rocket propellants," Eurasian Chem. Technol. J., vol. 18, no. 3. pp. 197-206, 2016.

[5] D. Sandaram, V. Young, V. E. Zarko, "Combustion of aluminum nanoparticles (review)," Combust. Explo. Shock+, vol. 51, no. 2, pp. 37-63, 2015.

* The work was supported by RFBR, project number 19-33-90015.