CONVECTIVE BURNING OF FINE-DISPERSED MIXTURES OF AMMONIUM NITRATE AND ALUMINUM IN A CLOSED-VOLUME BOMB

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Abstract: As the recent study shows, grinding of ammonium nitrate (AN) up to particle size of 20–40 μm strongly enhances propensity of the mixtures of AN with the fine-dispersed fuel powders to combustion-to-explosion transition. Especially, mixtures of fine-dispersed AN with Al demonstrate high intensity of combustion. Firings have been fulfilled in a closed-volume bomb and explosions were observed there in a stoichiometric mixture. The explosions arose at initial phase of convective burning, resulting in the abrupt pressure oscillations of several kilobars in amplitude. In this paper, the firings in a closed-volume bomb are analyzed with the use of numerical modeling. Dynamics of explosion development and features of reaction zone where two steps of chemical conversion (burning of the AN and combustion of Al particles in atmosphere of gaseous AN decomposition products) have been considered in detail, and effects of Al content, AN particle size, charge length, and pressure generated by igniter on the mode and behavior of the convective burning wave are studied. The modeling results are in good qualitative agreement with experimental data.

Keywords: convective burning; explosion; closed-volume bomb; ammonium nitrate; aluminum

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References

1. Khrapovskii, V. E., V. G. Khudaverdiev, and A. A. Sulimov. 2011. Konvektivnoe gorenie smesey ammiachnoy selitry s drevesnym uglem [Convective burning of the mixtures of ammonium nitrate and charcoal]. *Goren. Vzryv (Mosk.) — Combustion and Explosion* 4:172–175.
2. Khrapovskii, V. E., V. G. Khudaverdiev, and A. A. Sulimov. 2013. Konvektivnoe gorenie i perekhod vo vzryv v melkodispersnykh smesyakh ammiachnoy selitry s alyuminiem [Convective burning and transition to explosion in fine mixtures of ammonium nitrate with aluminum]. *Goren. Vzryv (Mosk.) — Combustion and Explosion* 6:211–213.
3. Ermolaev, B. S., A. A. Belyaev, and A. A. Sulimov. 2005. Chislennoe modelirovanie konvektivnogo goreniya poristykh smesevykh sistem na osnove melkodispersnogo alyuminiya i perkhlorata ammoniya [Numerical modeling of convective burning of porous mixture systems based on fine-dispersed powders of aluminum and ammonium perchlorate]. *Khim. Fiz.* 24(1):79–89.

4. Pochil, P. F., A. F. Belyaev, Yu. V. Frolov, *et al*. 1972. Gorenie poroshkovykh metallov v aktivnykh sredakh [Combustion of powder metals in active media]. Moscow, Russia: Nauka. 294 p.

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