ENERGY CHARACTERISTICS OF UNDERWATER EXPLOSION OF NONIDEAL ALUMINUM-RICH EXPLOSIVE MIXTURES: COMPARISON WITH CONVENTIONAL HIGH EXPLOSIVES

P. V. Komissarov[1,2], A. A. Borisov[1], G. N. Sokolov[1], and V. V. Lavrov[3]

[1]N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation
[2]National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe Sh., Moscow 115409, Russian Federation
[3]Institute of Problems of Chemical Physics, Russian Academy of Sciences, Chernogolovka, Moscow Region, Russian Federation

Abstract: Experiments with small composite aluminum-rich charges being exploded in a reasonably small water vessel have demonstrated that the excess aluminum reacts quite fast and efficiently with surrounding water. These reactions have increased significantly the overall specific explosion energy to values that are much greater than those inherent in energetic materials usually used in practical application for underwater explosions. The aforesaid findings call for larger-scale tests with the use of appropriate instrumentation. Such tests have been conducted in a 15 m^3 vessel with charges up to 50 g in mass.

Keywords: underwater explosion; hydroshock wave; nonideal explosion; Al–water reactions; bubble heave energy; shock wave energy; aluminized explosives

References

1. Cole, R. H. 1980. *Underwater explosions*. Ann Arbor, MI: University Microfilms International. 457 p.
2. Zhou, L., Z. Xie, and X. Wei. 2011. Comparison of underwater shock wave attenuation of a new insensitive high explosive with different explosives. *Combust. Explo. Shock Waves* 47(6):721.
3. Komissarov, P. V., B. S. Ermolaev, G. N. Sokolov, and A. A. Borisov. 2011. Convective burning and detonability of aluminum-rich ammonium perchlorate–aluminum–nitromethane mixtures: 1. Experiment. *Russ. J. Phys. Chem. B* 5(3):502–512.
4. *Komissarov, P. V., B. S. Ermolaev, G. N. Sokolov, and A. A. Borisov*. 2012. Theoretical issues of steady nonideal detonation in the ternary nitromethane – ammonium perchlorate – aluminum system. *Russ. J. Phys. Chem. B* 6(5):613–625.
5. Komissarov, P. V., G. N. Sokolov, B. S. Ermolaev, and A. A. Borisov. 2011. Smesevye sostavy dlya podvodnykh vzryvov s usilennym deystviem za schet vklyucheniya vody kak vneshnego okislitelya i ikh vzryvnye kharakteristiki [Composite explosives for underwater explosions enhanced by inclusion of water as an external oxidizer and their performance]. *Fiziko-khimicheskaya kinetika v gazovoy dinamike* [Physical-Chemical Kinetics in Gas Dynamics] 12(1):5. Available at: http://chemphys.edu.ru/media/published/2011-04-27-001.pdf (accessed October 17, 2016).

6. Komissarov, P. V., R. Kh. Ibragimov, A. A. Borisov, and G. N. Sokolov. 2009. Effektivnost' podvodnogo vzryva, voznikayushchego pri bystrom inzhektirovanii goryachikh chastits alyuminiya v vodu [Efficiency of the underwater explosion arising at fast injecting of hot particles of aluminum in water]. *Goren. Vzryv (Mosk.) — Combustion and Explosion* 2:87–90.
7. Komissarov, P. V., G. N. Sokolov, and A. A. Borisov. 2011. Characteristics of the underwater explosion of a nonideally detonating aluminum-rich energetic material. *Russ. J. Phys. Chem. B* 5(1):116–123.
8. Strømsøe, E., and S. W. Eriksen. 1990. Performance of high explosives in underwater ПХАplications. Part 2: Aluminized explosives. *Propell. Explos. Pyrot.* 15(2):52–53.
9. Paterson, S., and A. H. Begg. 1978. Underwater explosion. *Propell. Explosives* 3:63–69.
10. Bjarnholt, G. 1980. Suggestions on standards for measurement and data evaluation in the underwater explosion test. *Propell. Explosives* 5:67–74.
11. Hagfors, M., and J. Saavalainen. 2010. Underwater explosions — particle size effect of Al powder to the energy content of an emulsion explosive. *36th Annual Conference on Explosives and Blasting Technique Proceedings*. Cleveland, OH: Society of Explosives. 1:191–206.
12. Orlenko, L. P., ed. 2002. *Fizika vzryva* [Explosion physics]. Moscow: Fizmatlit. Vol. 1. 133 p.

Received December 18, 2015

Contributors

Komissarov Pavel V. (b. 1974) — Candidate of Science in physics and mathematics, senior research scientist, N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; lecturer, National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe Sh., Moscow 115409, Russian Federation; kr_899@yahoo.com

Borisov Anatoliy A. (b. 1932) — Doctor of Science in physics and mathematics, chief research scientist, N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; professor, National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe Sh., Moscow 115409, Russian Federation; borisov@chph.ras.ru

Sokolov Georgiy N. (b. 1983) — research scientist, N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; sokolov_gn@inbox.ru

Lavrov Vladimir . (b. 1958) — Candidate of Science in physics and mathematics, senior research scientist, The Institute of Problems of Chemical Physics, Russian Academy of Sciences, Chernogolovka, Moscow region, Russia; lavr@ficp.ac.ru