Analysis of fragmentation and brisance characteristics of new explosive compositions using the Russian Standard Fragmenting Cylinder no. 12

© A.V. Barmin[1], Yu.G. Pechenev[1], V.A. Odintsov[2], N.A. Imkhovik[2], I.P. Machneva[2]

[1] JSC State scientific research institute Kristall, Dzerzhinsk, Nizhny Novgorod Region, 606007, Russia
[2] Bauman Moscow State Technical University, Moscow, 105005, Russia

We analysed the results of statistical processing of fragment masses obtained in testing closed-end standard fragmenting cylinders no. 12 (RSFC — Russian Standard Fragmenting Cylinder) filled with the following explosive materials: four standard types and eight newly developed by the JSC State scientific research institute Kristall (four castable and four cold-pressed compositions). RSFC casings were manufactured from the C60 and 80G2S steels by lathing and stamping. We used the following combinations of steel and explosive to discuss the specifics of statistical fragment mass processing for the RSFC no. 12 according to a new fragmentation spectrum processing technique, the Odintsov method (patent no. 2362968RU): C60 — GASS-8 and C60 — GASS-12. We analysed the correlations between two main mass and numerical fragmentation spectrum characteristics ($N_{0,25}$, μ_c) *of the no. 12 RSFC stamped out of normalised artillery shell steel C60 and eutectoid steel 80G2S, and the following explosive composition properties: detonation velocity, Chapman–Jouguet pressure and shell expansion rate* W_{15} *— according to the T-20 technique. We determined that there exist these very close associations:* $W_{15} — N_{0,25}$ *and* $W_{15} — \mu_c$ (*correlation coefficient* $r \geq 0{,}94$), *which indicates that the dependence between acceleration potential and brisance of explosive compositions is close to being a function.*

Keywords: *Russian Standard Fragmenting Cylinder, explosive fragmentation, fragmentation spectrum, explosive compositions, detonation properties, acceleration potential, correlations*

REFERENCES

[1] Babkin A.V., Veldanov V.A., Gryaznov E.F. et al. *Boepripasy* [Munitions]. In 2 vols. Vol. 1. Selivanov V.V., ed. 3rd ed., revised. Moscow, BMSTU Publ., 2016, 506 p.

[2] Osipova L., Parfenov D., Nikiforov V. *Obozrenie armii i flota — Army and Navy Review*, 2007, no. 2, pp. 32–35.

[3] Odintsov V.A. *Konstruktsii oskolochnykh boepripasov* [Fragmentation munition designs]. *Part 2. Artilleriyskie snaryady* [Artillery shells]. Moscow, BMSTU Publ., 2002, 56 p.

[4] Odintsov V.A. Dvukhkomponentnaya model spektra razrusheniya tsilindrov [Dual-lobe model of cylinder fragmentation spectrum]. *Mekhanika impulsnykh protsessov. Tr. MVTU im. N.E. Baumana* [Pulse process mechanics. Proc. of the Bauman MHTS], no. 387. Moscow, Bauman Moscow Higher Technical School, 1982, 56 p.

[5] Odintsov V.A. *Modelirovanie protsessov fragmentatsii s pomoshchyu unifitsirovannykh tsilindrov* [Simulating fragmentation processes using standard cylinders]. Moscow, BMSTU Publ., 1991, 60 p.

[6] Andreev S.G., Babkin A.V., Baum F.A. et al. *Fizika vzryva* [Physics of Explosion]. In 2 vols. Vol. 2. Orlenko L.P., ed. 3rd ed., revised. Moscow, FIZMATLIT Publ., 2004, 656 p.

[7] Sternberg H.M. Fragment weight distributions from natural fragmenting cylinders loaded with various explosives. *NOLTR 73–83*, Naval Ordnance Laboratory, Maryland, 1973.

[8] Crowe C.R., Mock W., Holt W.H., Criffin O.H. Dynamic fracture and fragmentation of cylinders. *TR-3449*, Naval Surface Weapon Center, Dahlren laboratory, 1976.

[9] Odintsov V.A. *Izvestiya RAN. Mekhanika tverdogo tela — Mechanics of Solids*, 1992, no. 5, pp. 48–55.

[10] Odintsov V.A., Shkalyabin I.O. *Fizika goreniya i vzryva — Combustion, Explosion and Shock Waves*, 1994, no. 3, pp. 147–150.

[11] Shkalyabin I.O., Odintsov V.A., Kolganov E.V. Prognozirovanie effektivnosti smesevykh i individualnykh VV v oskolochnykh boepripasakh [Predicting fragmenation munition performance of composite and chemically pure compound explosives]. *Sb. dokl. nauch. konf. VRTs RARAN: Sovremennye metody proektirovaniya i otrabotki raketno-artilleriyskogo vooruzheniya* [Proc. of the Scientific Conference of the Volga Regional Center, Russian Academy of Missile and Artillery Sciences: Contemporary design and testing methods for missiles and artillery]. Sarov, All-Russian Research Institute Of Experimental Physics Publ., 2000, pp. 404–407.

[12] Odintsov V.A., Barmin A.V., Imkhovik N.A. *Inzhenernyy zhurnal: nauka i innovatsii — Engineering Journal: Science and Innovation*, 2013, iss. 1 (13). DOI: 10.18698/2308-6033-2013-1-565

[13] Kulikov V.N., Osavchuk A.N., Imkhovik N.A., Odintsov V.A. *Inzhenernyy zhurnal: nauka i innovatsii — Engineering Journal: Science and Innovation*, 2013, iss. 1 (13). DOI: 10.18698/2308-6033-2013-1-564

[14] Imkhovik N.A., Odintsov V.A., Osavchuk A.N., Kulikov V.N. *Boepripasy i vysokoenergeticheskie kondensirovannye sistemy* (Munitions and high-energy condensed systems), 2017, no. 2, pp. 86–95.

[15] Kozhevnikov V.G., Barmin A.V., Evstifeev M.E., Karachev A.G., Kolganov E.V., Odintsov V.A., Imkhovik N.A. *Boepripasy i vysokoenergeticheskie kondensirovannye sistemy* (Munitions and high-energy condensed systems), 2010, no. 1, pp. 38–42.

[16] Barmin A.V., Evstifeev M.E., Ilin V.P., Kozhevnikov V.G., Odintsov V.A., Imkhovik N.A. *Oboronnaya tekhnika — Defence technology*, 2010, no. 1–2, pp. 15–19.

[17] Barmin A.V., Pechenev Yu.G., Karachev A.G., Kozhevnikov V.G., Shkalyabin I.O., Ilin V.P., Kolganov E.V., Odintsov V.A., Imkhovik N.A. *Oboronnaya tekhnika — Defence technology*, 2011, no. 2–3, pp. 15–20.

[18] Barmin A.V., Shkalyabin I.O., Kozhevnikov V.G., Kolganov E.V., Ilin V.P., Imkhovik N.A., Odintsov V.A. *Gorenie i vzryv — Combustion and Explosion*, 2012, vol. 5, no. 5, pp. 366–372.

[19] Barmin A.V., Karachev A.G., Kozhevnikov V.G., Kolganov E.V., Pechenev Yu.G., Odintsov V.A., Imkhovik N.A. *Voprosy oboronnoy tekhniki. Ser. 16. Tekhnicheskie sredstva protivodeystviya terrorizmu — Military Enginery. Scientific and Technical Journal. Counter-terrorism technical devices. Issue 16*, 2011, iss. 1–2, pp. 27–35.

[20] Odintsov V.A., Kolganov E.V., Barmin A.V., Imkhovik N.A., Shkalyabin I.O. *Voprosy oboronnoy tekhniki. Ser. 16. Tekhnicheskie sredstva protivodeystviya terrorizmu — Military Enginery. Scientific and Technical Journal. Counter-terrorism technical devices. Issue 16*, 2012, iss. 9–10, pp. 13–18.

[21] Barmin A.V., Gladtsinov A.V., Vlasov M.A., Odintsov V.A., Imkhovik N.A. *Gorenie i vzryv — Combustion and Explosion*, 2013, vol. 6, no. 6, pp. 315–319.
[22] Barmin A.V., Pechenev Yu.G., Evstifeev M.E., Karachev A.G., Odintsov V.A., Imkhovik N.A. *Gorenie i vzryv — Combustion and Explosion*, 2013, vol. 6, no. 6, pp. 320–326.
[23] Barmin A.V., Pechenev Yu.G., Odintsov V.A., Imkhovik N.A., Machneva I.P. Analiz oskolochnoy effektivnosti novykh vzryvchatykh sostavov s ispolzovaniem standartnogo oskolochnogo tsilindra RSFC № 12 [Fragmentation performance analysis of new explosive compositions using the no. 12 Russian Standard Fragmenting Cylinder]. *Materialy VIII Vseros. konf. "Energeticheskie kondensirovannye sistemy"* [Proc. of 8th All-Russian conference Condensed Energy Systems]. Chernogolovka, Dzerzhinskiy, Institute of Problems of Chemical Physics of RAS Publ., 2016, pp. 231–235.
[24] Kolganov E.V., Smirnov S.P., Smirnov A.S. Prostye metody rascheta kharakteristik detonatsii i obshchaya metodologiya razrabotki metodov otsenki parametrov vzryva [Simple methods of computing detonation characteristics and general methodology for developing explosion parameter estimation methods]. *Tr. Mezhdunar. konf. "IX Kharitonovskie tematicheskie nauchnye chteniya": Ekstremalnye sostoyaniya veshchestva, detonatsiya, udarnye volny* [Proc. of the International conference 9th Khariton Readings: Extreme states of matter, detonation, shock waves]. Sarov, Russian Federal Nuclear Center — All-Russian Research Institute of Experimental Physics Publ., 2007, pp. 144–146.
[25] Barmin A.V., Shkalyabin I.O., Kozhevnikov V.G., Kolganov E.V., Ilin V.P., Imkhovik N.A., Odintsov V.A., Reznichuk I.Yu. *Gorenie i vzryv — Combustion and Explosion*, 2012, vol. 5, no. 5, pp. 373–378.
[26] Grady D. *Fragmentation of Rings and Shells: The Legacy of N.F. Mott*. Springer, 2006, 376 p.

Barmin A.V., Engineer, JSC State scientific research institute Kristall. Author of 20 scientific publications and inventions in the field of physics of explosion, fracture mechanics, test techniques and foundations of fragmentation munition theory.

Pechenev Yu.G., Cand. Sc. (Eng.), Scientific Director, JSC State scientific research institute Kristall. Author of over 100 scientific publications, two monographs and over 40 patents.

Odintsov V.A., founder of the modern scientific school in the fragmentation munition theory. Author of over 200 scientific publications and over 120 patents, author of the GOST State Standard for standard fragmenting cylinder testing.

Imkhovik N.A., Cand. Sc. (Eng.), Assoc.Professor, Department of High-Precision Airborne Devices, Bauman Moscow State Technical University; Corresponding Member, Russian Academy of Natural Sciences. Author of over 150 scientific publications and 10 inventions in the field of chemical physics of combustion and explosion, theory of energetic materials, numerical simulation of detonation, theory of munition design and effect.
e-mail: imkhovik-n@mail.ru

Machneva I.P., Cand. Sc. (Eng.), Assoc.Professor, Department of High-Precision Airborne Devices, Bauman Moscow State Technical University. Author of 35 scientific publications and 8 inventions in the field of fragmentation munition effect theory, theory of energetic materials, chemical physics of combustion and explosion.