EXPERIMENTAL STUDY OF THE DEPENDENCE OF THE BURNING RATE OF HOMOGENEOUS ENERGETIC MATERIALS ON THE BURNING SURFACE CURVATURE

S. A. Rashkovskiy[1,2], V. G. Krupkin[1], and V. N. Marshakov[1]

[1]N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation
[2]A. Yu. Ishlinsky Institute for Problems in Mechanics, Russian Academy of Sciences, 101 Vernadskiy Av., Moscow 119526, Russian Federation

Abstract: For the first time, the dependence of the burning rate of a homogeneous condensed energetic material on the burning surface curvature is investigated experimentally. In the experiments, the grains of a double-base NB propellant with an artificially curved burning surface were used; namely, a double-slitpropellant grain and a grain in the form of thin wedge-shaped plates with different apex angles. As a result of the experiments, the dependences of the burning rate of a homogeneous condensed energetic material on the burning surface curvature were obtained and compared with the theoretical dependences obtained in the framework of Zel'dovich–Novozhilov phenomenological theory of unsteady combustion.

Keywords: solid homogeneous energetic materials; burning rate; burning surface curvature; experiment

DOI: 10.30826/CE19120413

Acknowledgments

This work was performed on the themes of the State Tasks Nos. AAAA-A17-117021310385-6 and AAAA-A17-117040610346-5 and was supported by the Russian Foundation for Basic Research, Grant 18-08-01454 a.

References

1. Markstein, G. H. 1964. *Nonsteady flame propagation*. Oxford: Pergamon. 338 p.
2. Marshakov, V. N., A. G. Istratov, V. I. Kolesnikov-Svinarev, and S. V. Finyakov. 2008. Extinction of a propellant upon contact with a wall or substrate. *Russ. J. Phys. Chem. B* 2(3):470–475.
3. Vishnivetskii, I. Ya., A. P. Denisyuk, and A. E. Fogel'zang. 1979. Critical conditions of ballistic powder combustion. *Combust. Explo. Shock Waves* 15(1):8–13.
4. Marshakov, V. N., and A. G. Istratov. 2007. Critical diameter and transverse waves of powder combustion. *Combust. Explo. Shock Waves* 43(2):188–193.
5. Michelson, W. 1889. Ueber die normale Entzundungsgeschwindigkeit Explosiver Gasgemische. *Annalender Physikund Chemie* 37:1–24.
6. Rashkovskii, S. A. 2011. Effect of the curvature of the burning surface of condensed energetic materials on the burning rate. *Combust. Explo. Shock Waves* 47(6):687–696.
7. Rashkovskiy, S. A., Y. M. Milyokhin, and A. V. Fedorychev. 2017. Combustion of solid propellants with energetic binders. *Chemical rocket propulsion*. Springer International Publishing. 383–401.
8. Novozhilov, B. V. 1973. *Nestatsionarnoe gorenie tverdykh raketnykh topliv* [Unsteady combustion of solid propellants]. Moscow: Nauka. 176 p.
9. Krupkin, V. G., V. N. Marshakov, and S. A. Rashkovskiy. 2019. Oscillating and cellular structures on the burning surface of solid homogeneous energetic materials. *Int. J. Energetic Materials Chemical Propulsion* 18(4):287–302. doi: 10.1615/IntJEnergeticMaterialsChemProp.2019027692.
10. Rashkovskiy, S. A., V. G. Krupkin., and V. N. Marshakov. 2019. Burning rate of solid homogeneous energetic materials with a curved burning surface. *J. Phys. Conf. Ser.* 1250:012041. doi: 10.1088/1742-6596/1250/1/01204111.
11. Krupkin, V. G., V. N. Marshakov, and S. A. Rashkovskiy. 2019. Michelson–Markstein effect in combustion of solid homogeneous energetic materials. *Combust. Flame* 205:415–421. doi: 10.1016/j.combustflame.2019.04.034.
12. Krupkin, V. G., V. N. Marshakov, and S. A. Rashkovskiy. 2019. Effect of the curvature of the burning surface on the burning rate of a solid homogeneous energetic material. *Combust. Flame* 208:45–50. doi: 10.1016/j.combustflame.2019.07.004.
13. Rashkovskii, S. A., Y. M. Milekhin., A. N. Klyuchnikov, and A. V. Fedorychev. 2012. Combustion mechanism of mixtures of binders capable of self-sustained combustion with inert and active fillers. *Combust. Explo. Shock Waves* 48(2):177–190.

Received November 18, 2019

Contributors

Rashkovskiy Sergey A. (b. 1957) — Doctor of Science in physics and mathematics, chief research scientist, A. Yu. Ishlinsky Institute for Problems in Mechanics, Russian Academy of Sciences, 101 Vernadskiy Av., Moscow 119526, Russian Federation; leading research scientist, N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; rash@ipmnet.ru

Krupkin Vladimir G. (b. 1949) — Doctor of Science in physics and mathematics, chief research scientist, N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; krupkin49@mail.ru

Marshakov Vladimir N. (b. 1935) — Doctor of Science in physics and mathematics, chief research scientist, N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; marsh_35@mail.ru