# COMBUSTION OF FUEL–AIR MIXTURE IN GAS CAVITY UNDER THE BOTTOM OF THE HIGH-SPEED VESSEL

S. M. Frolov[1], S. V. Platonov[2], K. A. Avdeev[1], V. S. Aksenov[1], V. S. Ivanov[1], A. E. Zangiev[1], A. S. Koval'[1], and F. S. Frolov[1]

[1]N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation
[2]Nizhniy Novgorod, Russian Federation

**Abstract:** A numerical study of the possibilities to reduce drag and to create additional thrust for the vessel with an artificial gas cavity under the bottom by means of organizing stationary combustion of fuel–air mixture in the cavity has been performed. It is shown that feeding the fuel mixture in the cavity and its subsequent burning under the bottom of the vessel can significantly increase the efficiency of the cavity with respect to the horizontal and vertical components of forces acting on the vessel by the gases in cavity. The results suggest that appropriate revision of the longitudinal profiling of bottom contours, for example, creating a cascade of transverse redans, may increase the horizontal force to the values, capable of ensuring the vessel to move with the target speed, and refuse in the future from the use of traditional screw propellers.

**Keywords:** high-speed vessel; artificial gas cavity; hydrodynamic drag; combustion; impulse of horizontal force

## Acknowledgments

This work was supported by the Russian Foundation for Basic Research (project ofi-m 16-29-01065).

## References

1. Butuzov, A. A. 1966. O predel'nykh parametrakh iskusstvennoy kaverny, obrazuemoy na nizhney poverkhnosti gorizontal'noy stenki [On limiting parameters of artificial cavity formed at the lower surface of horizontal plate]. *Izvestiya AN SSSR, Mekhanika Zhidkosti i Gaza* 2:167–170.
2. Avdeev, K. A., V. S. Aksenov, A. A. Borisov, R. R. Tukhvatullina, S. M. Frolov, and F. S. Frolov. 2015. Chislennoe modelirovanie peredachi impul'sa ot udarnoy volny k puzyr'kovoy srede [Numerical modeling of momentum transfer from a shock wave to bubbly medium]. *Goren. Vzryv (Mosk.) — Combustion and Explosion* 8(2):57–67.
3. Avdeev, K. A., V. S. Aksenov, A. A. Borisov, R. R. Tukhvatullina, S. M. Frolov, and F. S. Frolov. 2015. Numerical simulation of momentum transfer from a shock wave to a bubbly medium. *Russ. J. Phys. Chem. B* 9(3):363–374.
4. Avdeev, K. A., V. S. Aksenov, A. A. Borisov, S. M. Frolov, F. S. Frolov, and I. O. Shamshin. Momentum transfer from a shock wave to a bubbly liquid. *Russ. J. Phys. Chem. B* 9(6):895–900.
5. Hirt, C. W., and B. D. Nichols. 1981. Volume of fluid (VOF) method for the dynamics of free boundaries. *J. Comput. Phys.* 39(1):201–225.

6. Magnussen, B. F., and B. H. Hjertager. 1976. On mathematical modeling of turbulent combustion with special emphasis on soot formation and combustion. *16th Symposium (International) on Combustion Proceedings*. Pittsburg, PA: The Combustion Institute. 719–729.

*Received November 15, 2016*

## Contributors

**Frolov Sergey M.** (b. 1959) — Doctor of Science in physics and mathematics, head of department, N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; scientific head, Noncommercial Partnership Center of Pulse Detonation Combustion, 4 Kosygin Str., Moscow 119991, Russian Federation; professor, National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe Sh., Moscow 115409, Russian Federation; smfrol@chph.ras.ru

**Platonov Sergey V.** (b. 1971) — Candidate of Science in technology, Nizhniy Novgorod, Russian Federation; platsv@yandex.ru

**Avdeev Konstantin A.** (b. 1971) — Candidate of Science in technology, specialist, Noncommercial Partnership Center of Pulse Detonation Combustion, 4 Kosygin Str., Moscow 119991, Russian Federation; senior research scientist, N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; kaavdeev@mail.ru

**Aksenov Victor S.** (b. 1952) — 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; designer, Noncommercial Partnership Center of Pulse Detonation Combustion, 4 Kosygin Str., Moscow 119991, Russian Federation; associate professor, National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe Sh., Moscow 115409, Russian Federation; v.aksenov@mail.ru

**Ivanov Vladislav S.** (b. 1986) — 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; ivanov.vls@gmail.com

**Zangiev Alan E.** (b. 1989) — research engineer, N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; sydra777@gmail.com

**Koval' Alexey S.** (b. 1985) — research engineer, N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, 4 Kosygin Str., Moscow 119991, Russian Federation; designer, Noncommercial Partnership Center of Pulse Detonation Combustion, 4 Kosygin Str., Moscow 119991, Russian Federation; senior lectures, National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe Sh., Moscow 115409, Russian Federation; ASKoval@mephi.ru

**Frolov Fedor S.** (b. 1981) — 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; senior specialist, Noncommercial Partnership Center of Pulse Detonation Combustion, 4 Kosygin Str., Moscow 119991, Russian Federation; f.frolov@chph.ru