PACS: 52.80.Wq

The effect of discharge on water spray from a vortex nozzle at different pressures

A. S. Saveliev*, V. A. Panov, Yu. M. Kulikov

Joint Institute for High Temperatures of Russian Academy of Sciences
Bld. 2, 13 Izhorskaya st., Moscow, 125412 Russia
** E-mail: fisteh@mail.ru*

Received 15.04.2026; revised 28.05.2026; accepted 22.10.2026

The effect of a repetitively pulsed spark discharge initiated directly in the liquid film near the exit orifice of a vortex-type nozzle on the spatial atomization efficiency of water is studied experimentally. The discharge was ignited between a sharp high-voltage electrode (positive polarity, 14 kV) and the film surface. Measurements were performed over a discharge repetition frequency range of 0.1–40 kHz and water gauge pressures from 0.5 to 4 bar. Using high-speed shadowgraphy, the spray cone width was quantified, and the parameter H/H_0 was introduced to characterize the relative enhancement of spatial atomization when the discharge is applied. The H/H_0 vs. frequency dependence is found to be non-monotonic with a pronounced maximum; the frequency of this maximum shifts to higher values with increasing water pressure, while the peak magnitude decreases. Electrical measurements yield a single-discharge energy estimate of ~ 1 mJ and confirm the absence of misfires over the entire frequency range. The observed effect is attributed to the compression wave generated in the discharge channel, which imparts an additional radial momentum to the droplets and causes earlier film breakup. The energy efficiency of the method is discussed for different water pressures.

Keywords: aerosol, spark discharge, nozzle.

REFERENCES

1. Rayleigh L., Proceedings of the London Mathematical Society **s1-10** (1), 4–13 (1878).
2. Tyler E., The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science **16** (105), 504–518 (1933).
3. Lefebvre A. H. and McDonell V. G. Atomization and Sprays. Boca Raton: CRC Press, 2017.
4. Handbook of Atomization and Sprays: Theory and Applications / ed. Ashgriz N. US: Springer, 2011.
5. Lozano A., Call C. J., and Dopazo C. Proceedings of the Sixth International Conference on Liquid Atomization and Spray Systems. Italy: Napoli, 2023, pp. 24–31.
6. Carvalho I., Heitor M., and Santos D., International Journal of Multiphase Flow **28** (5), 773–789 (2002).
7. Lenz H. P. Mixture Formation in Spark-Ignition Engines. Vienna: Springer, 1992.
8. ASM Handbook: Volume 7: Powder Metal Technologies and Applications 3rd ed. / ed. Lee P. W. Ohio: ASM International, 2006.
9. Eslamian M., Ahmed M., and Ashgriz N., Nanotechnology **17** (6), 1674–1685 (2006).
10. Jayanthi G. V., Zhang S. C., and Messing G. L., Aerosol Science and Technology **19** (4), 478–490 (1993).
11. Chau A., Eslamian M., and Ashgriz N., Particle and Particle Systems Characterization **25** (2), 183–191 (2008).
12. NIST Special Publication 1069. Advanced Technology for Fire Suppression in Aircraft / ed. Gann R. G. Gaithersburg, MD: National Institute of Standards and Technology, 2007.
13. Gong J., Fan W., and Peng J., International Journal of Precision Agricultural Aviation **2** (1), 26–30 (2019).
14. Benther J., Pelaez-Restrepo J., Stanley C., and Rosengarten G., International Journal of Heat and Mass Transfer **178**, 121587 (2021).
15. Hines R. L., Journal of Applied Physics **37** (7), 2730–2736 (1966).
16. Kowalczuk P. B. and Drzymala J., Particulate Science and Technology **34** (6), 645–647 (2016).
17. Kudryashova O., Shalunov A., Genne D., Dorovskikh R., and Titov S., Applied Sciences **13** (22), 12330 (2023).
18. Saveliev A. S. and Ugryumov A. V., Applied Physics, № 5, 33–39 (2024) [in Russian].
19. Saveliev A. S., Kulikov Yu. M., and Panov V. A., Vestnik Obedinennogo Instituta Vysokih Temperatur **17**, 7–10 (2025) [in Russian].
20. Saveliev A. S., Kulikov Yu. M., and Panov V. A., Vestnik Obedinennogo Instituta Vysokih Temperatur **18**, 1–8 (2025) [in Russian].
21. Sedov L. I. Metody podobiya i razmernosti v mekhanike (8-e izdanie). Moscow: Nauka, 1977 [in Russian].

Об авторах

Савельев Андрей Сергеевич, к.ф.-м.н., старший научный сотрудник, Объединенный институт высоких температур РАН (125412, Москва, Россия). E-mail: fisteh@mail.ru SPIN-код: 6888-7369, AuthorID: 866343

Панов Владислав Александрович, к.ф.-м.н., старший научный сотрудник, Объединенный институт высоких температур РАН (125412, Москва, Россия). E-mail: panovvladislav@gmail.com SPIN-код: 5821-2776, AuthorID: 755538

Куликов Юрий Матвеевич, к.ф.-м.н., старший научный сотрудник, Объединенный институт высоких температур РАН (125412, Москва, Россия). E-mail: kulikov-yurii@yandex.ru SPIN-код: 7719-8459, AuthorID: 1130937