DEFLAGRATION-TO-DETONATION TRANSITION IN "OXYGEN – LIQUID n-HEPTANE FILM" SYSTEM

S. M. Frolov[1,2,3], V. S. Aksenov[1,2,3], and I. O. Shamshin[1,2,3]

[1]Noncommercial Partnership Center of Pulse Detonation Combustion, 4 Kosygin Str., Moscow 119991, Russian Federation

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

[3]National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), 31 Kashirskoe Sh., Moscow 115409, Russian Federation

Abstract: Deflagration-to-detonation transition (DDT) in "gas-film" system with a weak ignition source, which does not generate the initial shock wave (SW) of any significant intensity, has been registered experimentally apparently for the first time. In a series of experiments with different ignition energy (14 to 480 J) in a straight smooth-walled 3-meter long channel of rectangular 54×24 mm cross section with one open end, the DDT in "gas (oxygen) – liquid fuel (n-heptane) film" system was obtained at run-up distances of 1 to 2 m from the ignition source with run-up times of 2.6 to 31 ms after ignition. Despite some differences in the dynamics of detonation onset from experiment to experiment, both with different and with the same ignition energy, the measured velocity of arising detonation wave (DW) was 1800–2000 m/s (77%–85% of the Chapman–Jouguet velocity) and did not dependent on the ignition energy, while registered pressure and luminosity profiles in the DW retained their shape. Analysis of the DW structure indicates that at the top of the leading front of the DW running over the liquid-film surface, there is an adjacent oblique shock wave inclined at an angle of about 45°. High-speed videorecording of DDT process development at the initial section of the channel showed that combustion occurs in the channel in a relatively thin layer over the liquid film and even on a relatively large time period comparable with the DDT run-up time combustion occupies only a part of channel cross section. In some experiments, a quasi-stationary low-speed detonation-like combustion fronts propagating at an average velocity of 700–900 m/s were detected apparently for the first time. The structure of these fronts includes a leading SW followed by a reaction zone separated from each other by a time delay of 80 to 150 μs.

Keywords: liquid fuel film; oxygen; deflagration-to-detonation transition; combustion modes; experiment; high-speed video

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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

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; engineer, 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

Shamshin Igor O. (b. 1975) — 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; specialist, 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; shamshin@idgcenter.ru