CATAPULT LAUNCHING TESTS OF AN UNMANNED AERIAL VEHICLE WITH A RAMJET PULSED-DETONATION ENGINE

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Abstract: The results of catapult launching tests of unmanned aerial vehicles (UAVs) with power plants based on one and two paired ramjet pulsed detonation engines (PDEs) are presented. The world's first autonomous flight of an UAV with a new type of ramjet power plant is demonstrated. The power plant includes an air intake with a mechanical check valve and detonation tube and is fueled by hydrocarbon fuels including regular aviation kerosene. At the speed of the approaching air flow from 30 to 120 m/s, the power plant provides the effective thrust up to 250 N with a fuel-based specific impulse of 1000–1200 s. The results of catapult launching tests of UAVs with a takeoff mass of up to 100 kg have shown that the PDE-based power plants provide a subsonic flight with acceleration and climbing. Due to the simplicity of design and low cost, as well as high propulsion performances, such power plants can be considered as an alternative to the propulsion units based on piston and turbojet engines for subsonic UAVs.

Keywords: pulsed detonation engine; power plant; experimental sample; catapult launching tests; thrust performance; specific impulse

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References

1. Frolov, S. M., ed. 2006. Impulsnye detonatsionnye dvigateli [Pulsed detonation engines]. Moscow: TORUS PRESS. 592 p.
2. Frolov, S. M., V. S. Aksenov, and V. Ya. Basevich. 2005. Air-breathing liquid-fueled pulse detonation engine demonstrator. *Dokl. Phys. Chem.* 402(2):93–95.
3. Frolov, S. M., V. S. Aksenov, and V. Ya. Basevich. 2006. Maket-demonstrator vozdushno-reaktivnogo dvigatelya s detonatsionnym szhiganiem topliva [Demonstrator of air-breathing engine with detonative combustion of fuel]. *Khim. Fiz.* 25(4):14–19.
4. Frolov, S. M., V. S. Aksenov, V. S. Ivanov, and I. O. Shamshin. 2016. Thrust characteristics of a pulse detonation engine operating on a liquid hydrocarbon fuel. *Russ. J. Phys. Chem. B* 10(2):291–297.
5. Frolov, S. M., V. S. Ivanov, I. O. Shamshin, and V. S. Aksenov. 2017. Ispytaniya modeli impul'sno-detonatsionnogo pryamotochnogo dvigatelya v svobodnoy vozdushnoy strue s chislom Makha do 0.85 [Tests of the pulsed-detonation ramjet model in a free air jet with Mach number up to 0.85]. *Goren. Vzryv (Mosk.) — Combustion and Explosion* 10(3):43–52.
6. Frolov, S. M., V. S. Ivanov, V. S. Aksenov, A. E. Zangiev, I. O. Shamshin, and P. A. Gusev. 2018. Impul'sno-detonatsionnyy tyagovyy modul' [Pulse detonation thrust module]. *Goren. Vzryv (Mosk.) — Combustion and Explosion* 11(3):92–102.
7. Frolov, S. M., S. A. Nabatnikov, G. G. Lazarev, I. O. Shamshin, K. A. Avdeev, V. S. Aksenov, and V. S. Ivanov. 2018. Sposob raboty impul'sno-detonatsionnogo dvigatelya v pole tsentrobezhnykh sil i ustroystvo dlya ego realizatsii v reaktivnom vertolyote [Method of operation of a pulsed detonation engine in the field of centrifugal forces and a device for its realization in a ramjet helicopter]. Application to the Patent of Russian Federation No. 2018142030 dated 29.11.2018.
8. Barr, L. May 16, 2008. Pulse detonation engine flies into history. *Air Force Print News Today*. Available at: http://ronney.usc.edu/AME514/Lecture12/PDE-Borealis_2008.pdf (accessed January 30, 2019)
9. Frolov, S. M. 2008. Fast deflagration-to-detonation transition. *Russ. J. Phys. Chem. B* 2(3):442–455.

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