PULSED-DETONATION HYDRORAMJET

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In [1], a water transportation engine of a novel type — a pulsed-detonation hydroramjet (PDH) — is designed, manufactured, and tested. The PDH is a pulsed detonation tube (DT) inserted in an open-ended water guide (Fig. 1). The thrust is developed by shock-induced pulsed jets of bubbly water periodically emanating from the water guide nozzle. Numerical simulations indicated that valveless and valved PDH models can produce thrust with the specific impulse on the level ranging from 600 to 2400 s. Test firings of PDH models of various designs with a 2-liter gasoline–oxygen fueled DT were carried out on a specially designed test rig which provides the approaching water flow in the form of a submerged jet at a speed of up to 10 m/s. The measured average specific impulse of valveless and valved PDH models was on the level of 350–400 s when the first operation cycle was not considered. The measured values of the average thrust and specific impulse in the first operation cycle were shown to be always much higher than those in the subsequent cycles: In the tests, the average value of thrust in the first cycle varied from 300 to 480 N and the value of the specific impulse varied from 960 to 2690 s, which indicates the potential of increasing the thrust performance. High-speed video records showed that after the first operation cycle, a significant volume of water in the form of liquid films and droplets is brought to the DT. Consequently, by the beginning of the second, third, and subsequent cycles, there is a considerable amount of water on the walls of the DT and in the DT volume. Thus, there is a need for undertaking special measures for preventing the penetration of water into

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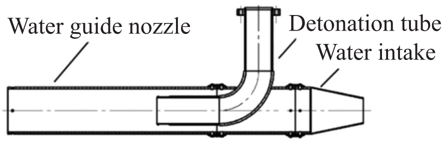

Figure 1 Schematic of the PDH

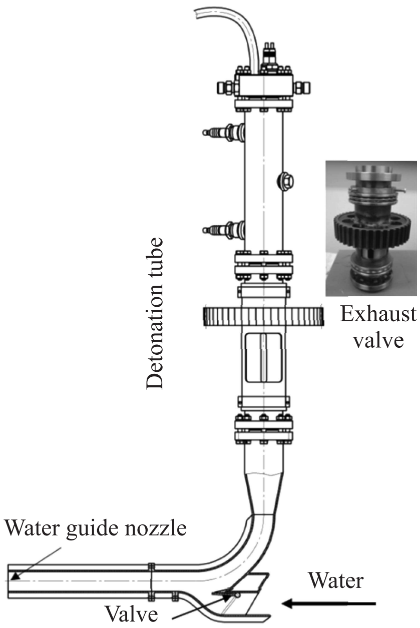

Figure 2 Modified PDH

the DT and ensuring repeatability of the conditions in the DT before each operation cycle. The objective of the work reported herein is to improve the propulsive performance of the valveless and valved PDH models.

Figure 2 shows the schematic of the modified valved PDH with the rotating exhaust valve installed in the DT for its venting after the detonation shot. Figure 3 compares the records of thrust and in-

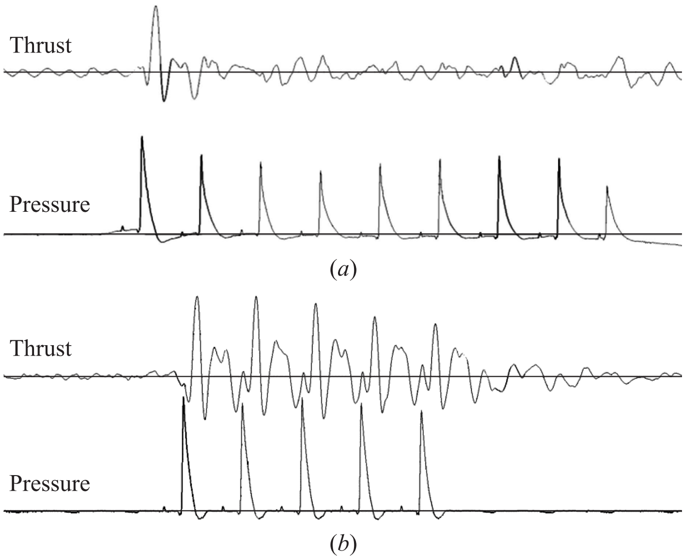

Figure 3 Thrust and in-chamber pressure records at deactivated (*a*) and activated (*b*) exhaust valve at PDH operation with 14 Hz

chamber pressure at the deactivated and activated exhaust valve at PDH operation with the frequency of 14 Hz using propane as a fuel. It is clearly seen that the use of the exhaust valve results in a more regular PDH operation: the cycle-to-cycle variability of thrust and in-chamber pressure records is considerably less and the first cycle is reproduced by each subsequent cycle. As a result, the thrust performance of the PDH increases considerably.

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References

1. Frolov, S. M., K. A. Avdeev, V. S. Aksenov, F. S. Frolov, I. A. Sadykov, I. O. Shamshin, and R. R. Tukhvatullina. 2019. Pulsed detonation hydroramjet: Simulations and experiments. *Shock Waves*. 14 p. doi: 10.1007/s00193-019-00906-2.