INVESTIGATION OF CYCLE-TO-CYCLE VARIABILITY AT OPERATION OF PULSED DETONATION HYDRORAMJET

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Abstract: The study is aimed at clarifying and eliminating the reasons of cycle-to-cycle variability during the operation of an innovative pulsed detonation hydroramjet (PDH) which reduces its thrust performance. An experimental sample of the PDH in the form of a pulsed detonation tube connected to an optically transparent water guide has been designed and manufactured. Experimental studies were performed with the vertical immersion of the sample in water. It was found that the cycle-to-cycle variability is associated with the overexpansion of gaseous detonation products in the detonation tube due to the inertia of the water column in the water guide. Gas overexpansion causes a reverse flow of the gas–water mixture which fills the water guide and penetrates the detonation tube, thus exerting a strong effect on the cyclic operation of the PDH. To eliminate the cycle-to-cycle variability, a new PDH model was developed, manufactured, and tested. The model is equipped with a rotary mechanical valve and operates on a propane–oxygen mixture. Its test fires showed that the use of the valve makes it possible to eliminate the cycle-to-cycle variability and to increase more than twice the average specific impulse: up to 550 s instead of 250 s at an operating frequency of 14 Hz.

Keywords: pulsed detonation hydroramjet; detonation wave; shock wave; bubbly water medium; specific impulse; thrust

DOI: 10.30826/CE21140105

Figure Captions

Figure 1 Schematic of PDH

Figure 2 Experimental sample of PDH with the detonation tube, transparent water guide, pressure sensor, and ionization probe

Figure 3 Frames of video record of water flow in the PDH water guide in two successive operation cycles. Distance between horizontal risks is 100 mm: (*a*) 0 ms; (*b*) 67.5; (*c*) 162.5; and (*d*) 345 ms

Figure 4 Time histories of pressure at the exit of the detonation tube in the first (*a*) and second (*b*) operation cycles

Figure 5 Schematic of the PDH model with a rotary valve (*a*) and the PDH model installed on the laboratory bench (*b*)

Figure 6 Cyclograms of PDH (*a*) and rotary valve (*b*) operation: $t_{\rm close}$ is the time interval when valve is closed; $t_{\rm open}$ is the time interval when valve is open; and $\Delta\tau_{\rm ign}$ is the time interval between the moments of ignition and valve opening

Figure 7 The PDH thrust and pressure at the outlet of the detonation tube with deactivated (*a*) and activated (*b*) rotary valve (operation frequency 14 Hz)

Figure 8 Experimental dependences of PDH thrust (*a*) and specific impulse (*b*) on the ignition delay $\Delta\tau_{\rm ign}$: *1* — 7 Hz; and *2* — 14 Hz. Horizontal dashed lines correspond to the thrust and specific impulse of PDH with deactivated valve (frequency 14 Hz)

Table Caption

Maximum pressure (P_a) and specific impulse ($I_{\rm sp}$) in three successive cycles in four test fires of the PDH

Acknowledgments

This research work was performed at the expense of a subsidy allocated by the N. N. Semenov Federal Research Center for Chemical Physics of the Russian Academy of Sciences to implement the State Task on the topic No. 0082-2019-0006 (Registration No. AAAA-A21-121011990037-8).

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Received February 14, 2021

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