AIR-BREATHING PULSE DETONATION THRUST MODULE

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Abstract: An air-breathing pulse detonation thrust module (TM) with a fuel-based specific impulse of up to 1500–1700 s is developed and tested on a ground test bench. The thermal state of TM structural elements, associated vibration loads, emitted noise, and available service lifetime are assessed. Thermal measurements show that the TM tube temperature increases along its length and reaches maximum values (700–750 °C) in the region of cyclic deflagration-to-detonation transition (DDT). Vibration analysis indicates that the fundamental frequency of TM structural vibrations corresponds to the operation frequency (up to 10 Hz) with a superimposed structural vibration frequency of 30–45 Hz. The measured acoustic pressure at a distance of $\sim$ 100 mm from the TM inlet is 170–175 dB. At an approaching airflow speed of 35 m/s, the available service lifetime of the most loaded element of the TM design — the check valve of the air intake — is about 40 min.

Keywords: pulse detonation engine; thrust module; low-octane gasoline; experimental sample; fuel-based specific impulse; thermal state; vibrations; noise; service lifetime

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Figure Captions

Figure 1 Original pulse-detonation TM [6]

Figure 2 Cyclogram of the TM operation control

Figure 3 Schematic of the TM test bench

Figure 4 Typical records of ionization probes: (*a*) with DDT; and (*b*) without DDT

Figure 5 Measured time history of airflow velocity during TM test fire: *1* — real; and *2* — adjusted to 15 °C

Figure 6 Measured time histories of air temperature at the blower outlet (*a*), TM operation frequency (*b*), fuel mass flow rate (*c*), and fuel-based specific impulse of the TM (*d*) during TM test fire

Figure 7 Measured time history of TM thrust during TM test fire: *1* — mean; and *2* — real

Figure 8 Comparison of the measured thrust vs. air flow velocity dependencies for the modified TM (circles) and the original TM (shaded area). Curves correspond to the calculated dependencies of the total thrust (*1*), effective thrust (*2*), and aerodynamic drag (*3*) on the air flow velocity [6]

Figure 9 Time histories of the TM wall temperature measured by thermocouples T1–T3

Figure 10 Example of ionization probe records during parasitic ignition of fuel–air mixture on the hot wall of the TM

Figure 11 Time histories of acoustic pressure measured at a distance of 100 mm from the TM intake using sensors of total (*1*) and static (*2*) pressure of the approaching air flow

Figure 12 Valve flaps after TM operation for 40 min

Table Captions

Table 1 Parameters of the TM operation control cyclogram

Table 2 Main measured parameters during TM test fires

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