

CONSIDERING DISSIPATIVE FORCES FOR MATHEMATICAL MODELING LONGITUDINAL VIBRATIONS OF LIQUID LAUNCH VEHICLE BODY

The effects of fluid filling the propellant tanks on the characteristics of the dominant harmonics of the longitudinal vibrations of the launch vehicle body with a tandem configuration of stages are analyzed using the updated model of the longitudinal vibrations of a multi-stage liquid launch vehicle (LV). This model describes the longitudinal vibrations of the LV body as the mechanical vibrations of the multi-coupled dissipative system of the LV design and the liquid propellant in tanks. It is shown that the parameters of the natural longitudinal oscillation of a liquid propellant in the LV tanks strongly affect the frequencies and decrements of deeper tones of the natural longitudinal oscillation of the LV body playing a crucial role in the mechanism of losses in the longitudinal stability of liquid rockets.

In the context of a model of a viscous friction for mathematical describing a vibratory motion of the flexible body of the liquid launch liquid the experimental values of the damping coefficients for vibrations of the LV load-carrying structures and structurally similar models of liquid rockets are analyzed and generalized based on the available open-literature information. In particular, the results of the analysis of the dynamic tests of liquid rockets and their structurally similar models are given: a physical 1:6.5 scale model of the Zenit LV, the 15A15 rocket and its physical 1:3.7 scale model, a physical 1:5 scale model of the prototype of the Dnepr LV and its lowermost stages. An analysis of experimental data resulted in the development of methodic recommendations for calculating dissipation of energy of vibrations of the LV structures and damping vibrations of the liquid fuel in their tanks in building the finite-element models of the longitudinal vibrations of the liquid LV body, including conditions of the resonance growth of amplitudes of the LV body vibrations.

Keywords: *liquid launch vehicle, longitudinal vibrations, dissipation of energy, structural damping, viscous friction, parameters of natural oscillation.*

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