Conditions for gas cavity collapse in fluid during the transition from weightlessness to short-term exposure to individual G-force pulses

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We present experimental investigation results for the gas cavity collapse processes in propellant tanks of liquid propellant rocket propulsion plants under free (nonperturbed) orbital (suborbital) flight conditions, subjected to short-term individual g-force pulses. We defined the structure of dimensionless groups that link the maximum cavity volume to the amplitude and duration of a g-force pulse and to the physical properties of the fluid, so that the cavity does not collapse under the influence of the buoyant force when floating up. We carried out our experimental investigation using a weightlessness bench implementing reduced gravity conditions during free fall of the equipment being tested, and employing a flying laboratory moving along a Keplerian parabola. Results of the experimental studies mean that the nature of the collapse process in the case of free gas cavities subjected to individual g-force pulses is determined by the dimensionless pulse duration value and by the surface tension to viscosity ratio. Short-term g-force pulses make it possible to disregard the effect of viscosity upon the gas cavity collapse process. The cavity collapse, if it takes place, happens when the pulse duration is over, and is caused by fluid motion in the bottom hemisphere of the cavity. When the g-force pulse duration is significant, the pulse-induced cavity motion in the fluid becomes quasi-stationary, and the free surface stability is determined by the mass-force field intensity, the capillary viscosity radius parameter being fixed.

Keywords: *liquid propellant rocket propulsion plant, propellant tank, weightlessness, g-force, gas cavity, strain, collapse, experimental studies*

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