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DESIGN OPTIMIZATION OF CUBIC IN SHAPE PRESSURANT TANK FOR CUBESAT'S PROPULSION SYSTEM

Abstract

Cold gas propulsion for nanosatellites is one of the most rational system from a technical and economic point of view. However, there is a problem: the optimal spherical shape of the high-pressure vessel occupies only half of the cubic volume of the CubeSat unit. To increase the volume switching to a cubic-shaped tank is proposed. The aim of the work is to synthesize the most rational power scheme of the cubic in shape pressurant tank, which provides the best combination of the mass of the structure and the available delta-V budget of the propulsion system. The following variants are proposed: a complex of 4 cylinders with spherical bottoms; face-centered cubic packing of 14 equal spheres; a thin-walled cube supported by ribs, the location and parameters of which provide the smallest mass of the structure; a cube, the reinforcement scheme of which is calculated by topology optimization method; an original polyspheric design in which the filling of the volume of the cube is made by a set of spherical shells of different radii. All the considered variants of vessel can be obtained using additive technologies, for example, by selective laser sintering. For each variant, the internal volume and mass of the cylinders were obtained, as well as the delta-V budget, obtained taking into account the mass of the tank and the mass of the stored gas. Analysis of the results shows that there are two most rational structures. A cube supported by ribs provides the largest delta-V budget, but has the largest mass. The polyspherical design provides almost 1 m/s less margin of characteristic speed, but has 0.4 kg less mass. It should be noted that the difference in the mass of the cylinders is not a critical value for the CubeSat form factor satellites. A larger delta-V budget may be a more important factor when choosing a rational design. It is shown the possibility of increasing the reserve of delta-V of the CubeSat cold gas propulsion system by 30 ... 40% due to the transition from a spherical to a cube-shaped tank. At the same time, the mass of the tank structure increases in 1.7 ... 4.8 times, which can be considered an acceptable price for increasing the efficiency of the propulsion system. The best combination of mass and the reserve of characteristic velocity is given by the polyspheric power scheme.