Unloading the angular momentum of spacecraft using internal gravitational dampers

Anton V. Doroshin*

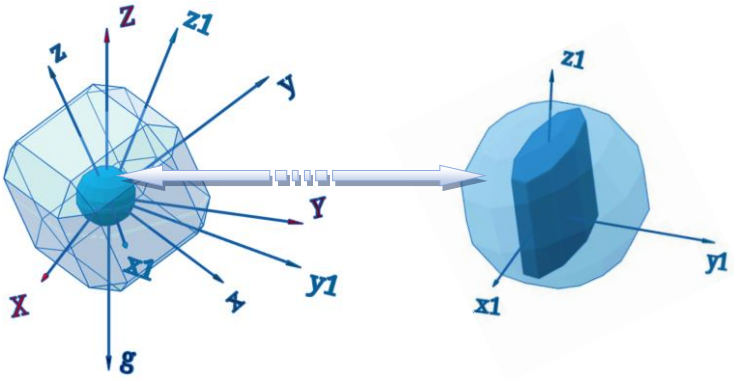
**Institute of Space-Rocket Engineering, Samara National Research University, Samara, Russia*

Abstract. The special dissipative method of spacecraft angular momentum unloading is considered. The method implies the interaction of the main body of spacecraft with the internal damper, rotating relative the main body in cavity with dissipative resistance medium (liquid, etc.). The damper body represents the three-axial body with the different general inertia moments, which try to take its orient according the action of gravitation central forces. So, the damper-body rotates in the inertial space due to gravitational forces, and therefore, it fulfils the rotation relative the main body of the spacecraft. Then between the main body and the damper-body the dissipative torque is acted due to resistance of liquid-type friction, which unloads the angular momentum of the spacecraft.

Introduction

As it is well known, the problem of spacecraft attitude control implies the possibility of the saturation of reaction/momentum wheels that assumes the large value of the angular momentum of the system (spacecraft and its rotors-wheels). Therefore, the task of unloading the angular momentum is one of important tasks of spacecraft attitude dynamics. The angular momentum of reaction/momentum wheels can be transferred to the main spacecraft body using internal interaction [1, 2], and after this translation the angular momentum value can be decreased with the help of interaction with the external forces, e.g. central gravitational forces, which are acting on spacecraft moving along the orbit.

In the presented paper the scheme of the gravitational unloading is proposed. This scheme (fig.1-a) uses the internal body (with different general inertia moments) placed in the spherical cavity with resistance liquid (fig.1-b). It is clear, that at the motion along the orbit this internal body tries to rotate and to place the gravity-oriented spatial position, due to the properties of the gravitational stabilization principles. At this internal rotation the dissipative torques arise, which acted on the main body of spacecraft and decelerate its angular motion. So, in the result the angular momentum of spacecraft will decrease.



(a) (b)

Figure 1: The spacecraft with the spherical cavity (a) and the internal gravitational damper in the cavity (b).

Results and discussion

The study the motion of spacecraft with the internal gravitational damper will be described by the equations of system written in the orbital coordinate systems XYZ, where Z correspond to the orbital radius vector (**g** is the gradient vector of the central gravity). The main body of spacecraft has the connected frame xyz, and the damper-body – $x_1y_1z_1$. The equations will be written basing on the law of the angular momentum changing, taking into account the gravitational torques and dissipative torques, acting on two bodies of the spacecraft, and the unloading of the angular momentum of the spacecraft moving along the circular orbit will be studied.

The work is supported by the Russian Science Foundation (#19-19-00085).

References

[1] A.V. Doroshin, Attitude Control of Spider-type Multiple-rotor Rigid Bodies Systems. Proceedings of the World Congress on Engineering 2009, London, U.K. Vol II, pp.1544-1549.

[2] A.V. Doroshin, Homoclinic solutions and motion chaotization in attitude dynamics of a multi-spin spacecraft (2014) Communications in Nonlinear Science and Numerical Simulation, 19 (7), pp. 2528-2552.