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Author: Dr. Yaroslav Mashtakov
Keldysh Institute of Applied Mathematics of RAS, Russian Federation, Mashtakov@keldysh.ru

Dr. Stepan Tkachev
Keldysh Institute of Applied Mathematics, RAS, Russian Federation, stevens_l@mail.ru

REACTION WHEELS ANGULAR MOMENTUM MANAGEMENT DURING INTERPLANETARY FLIGHT

Abstract

Traditionally high-thrust chemical propulsion systems are used for interplanetary flights. They can greatly change velocity of the satellite and provide very fast manoeuvres. However, due to rather low specific impulse, they require large amount of propellant.

The other approach is to use the low-thrust systems based on plasma or ion thrusters. They have much higher specific impulse, which makes it possible to provide up to tens of kilometers per second delta-v. As a result of rather low thrust, operating time of such systems increases to weeks and even months. The accurate attitude stabilization of the thrust axis must be ensured for the whole period of propulsion system operation. Typically, the set of reaction wheels is used for this purpose.

Note that propulsion system actually affects not only orbital but also angular motion. Due to misalignment of the thrust axis and center of mass location, the thruster would create the constant disturbing torque, which must be compensated by the attitude control system. This, in turn, would lead to the reaction wheels' saturation. In low Earth orbits we can use magnetorquers for desaturation, but during the interplanetary flight there would be no magnetic field, so the only option is the utilization of special attitude thrusters. They would require propellant, thus affecting the possible payload mass.

In this paper we consider several approaches that allow us to reduce the saturation rate of reaction wheels. Since the main requirement is to ensure the necessary stabilization of the thrust axis, there would be some freedom in satellite's attitude. For example, constant spin around the thrust vector allows us to "average" the disturbing torque, and to significantly decrease its effect on the reaction wheels saturation. However, it might greatly affect the power generation provided by solar arrays. In order to overcome this drawback, we consider mode of motion where the satellite periodically rotates around thrust vector by 180 degrees. It allows to simultaneously "average" disturbing torque and provide the necessary power generation.