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SPHERICAL REACTION WHEEL FOR MICROSATELLITE ATTITUDE CONTROL

Abstract

In this paper, a miniaturized spherical reaction wheel able to rotate about arbitrary axis is presented. Compared with conventional reaction wheels, the innovative spherical actuator could enhance robustness of a spacecraft's attitude control system. For a satellite with certain targeting requirements, an assembly of three wheels is vulnerable. Non-functionality of any wheel would lead to mission degradation or even failure. However, for spherical wheels, reconfiguration of remaining wheels' momentum direction enables mission to continue operations. By now, some designs about analogous spherical actuators have been proposed or even developed. Nevertheless, there is none suitable to be applied to small satellites. Limited mass, volume and power budget make desirable momentum storage capability and efficiency challenging to achieve. Here, a new design concept is investigated. Performed numerical simulations demonstrate its feasibility for microsatellites attitude control. This paper pays special attention to the spherical reaction wheel's motor design. Based on existing different types of motors' characteristics analysis, a proper principle working mechanism has been selected through the analytic hierarchy process. Motor's modification to sphere and magnetic geometry's optimization are presented. Furthermore, to facilitate the rotor's omnidirectional rotation, active magnetic bearing is employed. The non-contact support method eliminates friction and wear issues. Feasibility of the proposed design is analysed through dynamic modelling and simulation. Decoupling of electromagnetic driving and levitation is also discussed. The spherical reaction wheel is expected to have a mass of less than 1 kg, with 4π rotational velocity up to 8,000 rpm. Power consumption will be limited within 10 W, including suspension and driving.