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A COMPARISON STUDY ON THE FEASIBILITY OF TWO LOW SLOSHING CONFIGURATIONS FOR SMALL SATELLITE MAGNETIC FLUID ACTUATION

Abstract

The advent of space race has impacted all spheres of life including communication, information technology, defence and security, weather monitoring and even health care. A direct consequence of this space race was the development of pioneering technology towards more efficient and cost-effective space missions. One area that witnessed a spark in research was spacecraft propulsion. While liquid, solid, and cryogenic fuels have been used to launch and inject satellites into orbit, the actuators for satellite manoeuvring are of several types ranging from traditional thrusters and reaction wheels to the relatively new ion thrusters and magnetic actuators.

To increase the longevity of the missions and to reduce the cost of in-space operations, work has been done to develop actuators that make use of the existing natural phenomena. While there has been some work done on the use of electrically charged actuators interacting with the magnetic field of Earth, the use of magnetic fluids is unexplored. Magnetic fluids like ferromagnetic, diamagnetic and paramagnetic fluids are magnetized in the presence of a magnetic field and controlling this magnetization can be used to control satellite motion. As with liquid propellants in rockets, the major concern with the use of magnetic fluids is sloshing.

This study proposes two configurations of magnetic fluid actuators that are designed to reduce the onboard sloshing on a small foldable PCB-type satellite The first configuration would involve the positioning of magnetic fluid filled capillaries along the edges of the satellite and more over the surfaces according to the actuation requirements. The other configuration involves the use of magnetic fluid sheets over the surfaces of the satellite. Both these configurations are suitable for such miniaturised satellites as they do not increase structural complexity. Moreover, fluids in capillary shaped vessels or sheets would leave little room for it to have an oscillatory. Analysis will be done to compute the necessary quantity of fluid, and this would subsequently be used to arrive at the overall dimensions of the capillaries and sheets.

For each of the proposed designs a major point of comparison would be torque generation, with particular attention to the time required to attain the desired torque and the constraints violations. Analysis will also be done for the choice of fluid considering their viscosities, magnetizations and the impact magnetic fields have on them. Further, simulations would be performed using a controller to aid in identification of the better of two configurations.