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PRELIMINARY ANALYSIS OF A SPACECRAFT ATTITUDE CONTROL SYSTEM USING A SHIFTING MASS DISTRIBUTION

Abstract

This research examines the dynamics and the attitude control of a spacecraft by shifting mass distribution within the system. The behavior and use of conventional attitude control actuators are already fully developed and performing at the present time. However, the advantage of a shifting mass distribution concept can allow for completing three-axis attitude control, saving fuel, and extending a satellite's life. Shifting mass in fuel tanks involves changing the center-of-mass of the system, which in turns changes the moments of inertia of the system, which then ultimately can change the attitude of the system. The basic concept is six fuel tanks are equally distributed along the imaginary sphere. All tanks are assumed to be connected by massless pipes so fuel can be transferred from one tank to any other tank. Based on this fundamental design, governing equations of motion are developed and the feasibility of this system to achieve both attitude maneuvers and maintain stability will be presented.

The use of gravity-gradient control achieved by changing the mass distribution within satellite system is the key of this simulation. This long-term passive control can rotate a satellite's attitude around its moving reference frame. However, one of the difficulties we face is distributing fuel where it should be re-located exactly to achieve the moments of inertia required to keep the system stable. Various sets of constraints should be taken into account to obtain more improved solution. Since the amount of the torque obtained from gravity-gradient is quite small, auxiliary fuel tanks can be also added to the system, if needed. The result contains the possibility of mass distribution without any other actuators in a satellite's attitude control system. It also shows how the fuel shift can be used for the attitude control of a spacecraft system. However, additional development in finding the optimal control solution must be conducted. This study furthers the development of an integrated control system and addresses the challenges that remain.