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ATTITUDE CONTROL STRATEGY OF A TRANSFORMABLE SPACECRAFT FOR ORBITAL STATION-KEEPING AROUND SUN-EARTH L2

Abstract

Amplitude of natural halo orbits around the Sun-Earth L2 (SEL2), which is as much as 100,000 km or more, can be made smaller artificially by adding small amount of external force. This orbit is referred to as "the small-amplitude periodic orbit". From its relatively small size, the geometric relationship among a spacecraft, the sun and the earth is practically fixed, which leads to the advantage of making the thermal condition of spacecrafts more stationary. The magnitude of the force required for the orbit maintenance is comparable to solar radiation pressure (SRP) applied on a surface of a spacecraft, which means the small-amplitude periodic orbit can be achieved without fuel consumption if a spacecraft controls its attitude to receive SRP in the required direction. However, the SRP applied on a spacecraft to maintain this orbit also generates disturbance torque on the attitude motion, accumulating angular momentum that should be unloaded for motion stability. From this fact, it is necessary to develop a control law which solves the attitude-orbit coupled problem.

This study proposes the control law which unloads angular momentum and maintains the small-amplitude periodic orbit. This control is carried out by a combination of the orbit maintenance phase and the unloading phase. It extends the mission life time, improving the flexibility of the mission design as well as simplifying the thermal design. From these advantages, it is expected to open up new possibilities for future missions such as infrared space telescope missions and deep space port missions.

In this study, we assume a transformable spacecraft which consists of multiple movable panels connected by hinges with motors. The spacecraft can perform the fuel-free attitude control by using non-holonomic turn, which is realized by actuation of hinges in a specific order; concretely, if the spacecraft drives a panel A followed by a panel B and returns into the initial configuration actuating the panel A followed by the panel B, then the shape of the spacecraft is not changed consequently but its attitude is toward a different direction. Applying above-mentioned control strategy to this transformable spacecraft, it can keep staying on the small-amplitude periodic orbit around SEL2 being completely free from fuel consumption.

In this paper, basic theories of the dynamics are introduced first. Next, the control strategy is proposed, followed by its demonstration by numerical simulations. From its result, it is shown that this strategy is significantly effective for the transformable spacecraft.