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CONFIGURATION DESIGN OPTIMIZATION OF XENON ION PROPULSION SYSTEM THRUSTERS FOR GEOSTATIONARY SATELLITES

Abstract

This paper proposes a novel configuration design optimization scheme of Xenon Ion Propulsion System (XIPS) thrusters to effectively implement the low-thrust station-keeping for geostationary satellites. In this scheme, four XIPS thrusters are mounted on the antinadir face of the satellite through gimbal system in a rectangular shape as the initial configuration. This configuration has the merits of preventing the plume from corroding the solar array. Besides, this configuration also has the capability of achieving station-keeping and angular momentum dumping when one XIPS thruster has fault.

Considering the low-thrust feature of the XIPS thrusters, a tailored low-thrust station-keeping control strategy is developed to simultaneously operate the station-keeping maneuvers and angular momentum dumping. In this control strategy, a station-keeping period is two weeks including one two-day orbit determination period and six two-day control periods. The orbit determination period acquires the orbital elements as the inputs for control periods. In the control periods, the XIPS thrusters fire to compensate the perturbations to perform station-keeping and angular momentum dumping. In view of the firing performance, each XIPS thruster only fires once in a control period. The radial, tangential, and normal velocity increments generated by the four XIPS thrusters can be used for controlling the longitude drift rate, eccentricity, and orbital inclination to effectively achieve station-keeping. In the meantime, the thrust direction deviates the mass center of the satellite to generate moment for angular momentum dumping. For the maximum station-keeping efficiency, the XIPS thrusters fire in the ascending/descending nodes respectively.

Based on the control strategy, the installation position, on-orbit firing duration, and firing direction of each XIPS thruster are optimized using the genetic algorithm to minimize the total fuel consumption, subject to a number of engineering constraints including the station-keeping control accuracy and desired angular momentum dumping value. Finally, a practical geostationary satellite station-keeping example is investigated to demonstrate the effectiveness and practicality of the proposed optimization scheme. The simulation results show that the studied geostationary satellite can be maintained in an assigned station-keeping window while the angular momentum is dumped sufficiently. Moreover, the total fuel consumption of the optimized configuration is significantly decreased by 29.64%, which is beneficial to prolonging the on-orbit life of the satellite system.