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A NEW HINGED-ROD MODEL FOR DEPLOYMENT AND RETRIEVAL OF TETHERED SATELLITE SYSTEM

Abstract

Tethered Satellite System (TSS) is a new kind of space technique, which shows vast potential in application including space scientific experiments, space transportation, construction of large orbital architecture, etc. TSS is becoming a well-studied area in the past few decades. An important part of TSS study is the modeling of the tether. Because of the complexity of nonlinear dynamics of the flexible tether, accurate tether models are very difficult to obtain. Usually some approximations are applied. Two major ways to deal with the flexibility of the tether is establishing hybrid equations of motion using assumed node method (e.g., Galerkin's method) and modeling using lumped mass method. There are two common lumped mass models that have different load carrying units, which are named bead model and hinged-rod model respectively. Neither bead model nor hinged-rod model overwhelms each other in the application of tether modeling. But hinged-rod model shows higher accuracy in aerodynamic tether problem (e.g., Aero-assisted Orbital Maneuvering) for its simplicity to simulate aerodynamic forces along rod elements. Hinged-rod model also shows potential to reduce computational efforts while compared to bead model as higher accuracy of bead model demands larger number of beads. Although there were already a great deal of research works on hinged-rod tether model, few of them deal with the retrieval or deployment of the tether. The dimension of the rod element makes it more difficult to simulate tether length variation than that of bead model, so the original motivation of this paper is to settle this problem. Newton-Euler method rather than traditional Larangian or Kane method was adopted to establish the equations of motion because changing the number of equations, which happens during the retrieval and deployment of rod elements, is easier in the Newton-Euler method. Moreover, an approximate instantaneity treatment is applied to avoid the difficulty of modeling the changing dimension of the retrieving (or deploying) rod element. Simulation results proved that the new hinged-rod model proposed in this paper is effective in simulating the retrieval and deployment of the tether. The new model has some similarity to bead model but retains the advantages of traditional hinged-rod model, and it is rather simple to compare these two models by changing the length of rod elements while using this new model. Therefore, the new hinged rod model shows vast potential in future applications.