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DYNAMICS MODELING OF FLEXIBLE SPACECRAFT COMBINATION CONNECTED BY A SPACE MANIPULATOR

Abstract

Space manipulator is expected to play an increasingly important role in space operations and on-orbit service. After capturing a target spacecraft, the serving spacecraft and the target spacecraft constitute a combination under the connection of the space manipulator. When the serving and target spacecrafts are both large satellite platforms, the whole combination presents a dumbbell-like configuration with many flexible components, such as the links and joints of the space manipulator and the large solar arrays of the spacecrafts. Besides, the configuration of the combination is changing due to the operation of the space manipulator. In summary, the spacecraft combination connect by a space manipulator is a complex space combined mechanism with flexible multi-body, variable structure and low-fundamental frequency. There are many difficulties on the dynamics modeling of the spacecraft combination. Former researches used to pay more attentions to the flexibility of the links or joints of the space manipulator and ignore the flexibility of the solar arrays of the spacecrafts. They also used to ignore the initial motion of the spacecraft combination so as to simplify the problems. This paper focuses on the dynamics modeling of the flexible spacecraft combination connected by a space manipulator, considering all the flexibility of links, joints and solar arrays and taking into account the initial motion of the spacecraft combination. First, the flexible joints of the space manipulator are described by non-linear torsional spring models. Then, the kinetic energy of the spacecraft combination is derived base on the discrete expressions of the flexible links of the space manipulator and the flexible solar arrays of the spacecrafts by using of assumed mode method and finite element method. Furthermore, the dynamics models of the flexible spacecraft combination are established by the Lagrange equations and the conservation relationships of linear and angular momentum with non-zero initial values. Finally, forward and inverse dynamics simulations are performed in MATLAB combined with NASTRAN and ADAMS. The results illustrate that the modeling errors are less than 5% so that the dynamics models established in this paper are effective and accurate to represent the flexible spacecraft combination.