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STRUCTURAL DYNAMICS OF SUPER LARGE PLATE-LIKE GYROELASTIC SPACECRAFT WITH CONCENTRATED MASS MODELING

Abstract

In the ongoing advancement of aerospace technology, the trend of increasing spacecraft size is an important direction. This trend is exemplified by projects such as space solar power stations, large array reflective antennas, and the large-scale universal in-orbit service platform. These projects typically necessitate precise directional accuracy of the apparatus. Nonetheless, the enhanced structural flexibility resulting from the increased size of spacecraft, particularly the challenges presented by vibrational phenomena, significantly impedes the progression of these projects. One approach to mitigating this issue involves employing control moment gyroscopes for vibration suppression in flexible bodies, which are referred to as gyroelastic bodies. Studies on the dynamics of gyroelastic bodies reveal that the placement of control moment gyroscope clusters significantly influences the effectiveness of vibration suppression and the associated energy consumption. The present study focuses on investigating the structural dynamics of large, plate-like spacecraft and optimizing the configurations of control moment gyroscopes. The structural dynamics model for the gyroelastic body has been formulated using both the finite element method and the Lagrangian method. To address the issue of mass concentration arising from the installation of control moment gyroscope, a variable density function was employed to construct the mass matrix of units equipped with control moment gyroscope. Subsequently, a linear quadratic function representing the elastic potential energy and kinetic energy during the vibrational process of the structure was utilized as the cost function. With the installation positions of the control moment gyroscopes as variables, an enhanced Grey Wolf algorithm was applied to determine the optimal installation sites for various quantities of control moment gyroscopes. To address the issue of geometric discontinuities associated with using the numbers of the element as optimization variables, the variable description was altered to a geometric description, thereby enhancing the efficiency of solving the optimization problem. Ultimately, employing the same linear quadratic function as the cost function, a topology iteration algorithm was utilized to prioritize the installation positions of the control moment gyroscopes, offering valuable insights for orbital maintenance and construction activities. The findings indicate that control moment gyroscopes should initially be installed at the corners of plate-like spacecraft, proceeding thereafter to central positions and progressively expanding outward.