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HIGH FREQUENCY VIBRATION ISOLATION OF CONTROL MOMENT GYROSCOPE ON SATELLITES

Abstract

Compared with Thruster and Reaction Wheel, the Control Moment Gyroscope (CMG) can provide a larger output torque. Therefore, it is widely used as an actuator in the attitude control system of spacecraft.

However, the CMG generates inevitable vibration and degrades the performance of sensitive devices when it is used in controlling the spacecraft attitude. For some large spacecrafts, the vibration can be ignored. But some missions such as earth observing, broadcasting and telecommunication between antenna and ground stations require high precision and stability of the spacecraft. Therefore, vibration should be isolated to provide a quiet environment for spacecraft.

The vibration of CMG generally results from four sources: rotor imbalance, bearing disturbances, motor disturbances and motor driver errors. The present research focuses on the vibration caused by rotor imbalance which is generally the largest disturbance source and further causes disturbance force and torque at the rotor's spin rate.

Many researchers have done relevant studies. L. P. Davis discussed the vibration isolator for the Hubble Space Telescope (HST). The isolators function largely attenuate to high-frequency bearing-induced vibration along each wheel's spin axis. Karl J.P designed a passive reaction wheel jitter isolation system to meet the advance x-ray astrophysics facility (AXAF) imaging performance requirement. The isolation system can against multi-dimensional disturbances which aligned in a geometry commonly known as a Stewart platform arrangement. Allen J. B described a full spacecraft vibration isolator for the James Webb Space Telescope (JWST). The approach to the JWST isolation problem is to employ dual-stage passive isolation. This isolator further attenuates vibration disturbances from six reaction wheels before they propagate into the telescope.

In this paper, the passive isolation of vibration for the satellite with CMG is discussed. Firstly, the exact dynamic of the rigid spacecraft with CMGs is established. Then, the influence of the static imbalance and dynamic imbalance of the rotor to the stability and precision of spacecraft is analyzed. By analyzing the vibration in detail, specifications of the isolator is presented. What's more, the CMG isolation simulation for the whole spacecraft is designed. Finally, the results of simulation before and after using isolator are compared. The simulation results show that the isolator can greatly improve the precise and stability of the spacecraft.