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A NOVEL VIBRATION ISOLATION SYSTEM FOR REACTION WHEEL ON SPACE TELESCOPES

Abstract

Spacecraft with high pointing accuracy and stability becomes more and more important in space mission. For example, the Hubble Space Telescope (HST) required pointing stability to be less than 0.007 arcsecond within periods up to 24 hours. The James Webb Space Telescope needs the line of sight motion to be 4 milli-arcseconds.

For this class of spacecraft, attitude control torques are provided usually by reaction wheels (RWs) which can produce continuous torques to realize high precision pointing control and can perform large angle slewing maneuvers. However, due to imbalance of the rotor, imperfections in the spin bearings, motor disturbances and motor driven errors, the reaction wheel assembly (RWA) becomes one of the largest disturbance sources onboard the spacecraft. To mitigate these effects on the spacecraft pointing control, vibration isolation technology is often used for the reaction wheel. HST used viscous fluid dampers to attenuate the axial disturbances of the RWAs. The Chandra X-ray Observatory employed a hexapod isolator at each of its six RWs to achieve multi-dimensional vibration isolation.

During designing the above vibration isolation systems of RW, the researchers ignored that the RW should constantly adjust its speed to realize attitude stabilization or attitude maneuver. And it is obtained that the RW disturbance force is caused by the static imbalance of rotor, whose frequency is the same as the wheel speed. So a resonance condition will occur when the wheel speed and the corner frequencies of above vibration isolation systems come closer. If the resonance amplitude is large enough, the vibration isolation system will lose the ability of transferring effective torque, and cause rapid catastrophic attitude control system failure.

Therefore, a novel vibration isolation system which includes a multi-strut vibration isolation platform and the multiple tuned mass dampers is proposed in this paper. These multiple tuned mass dampers are appended to the upper platform. In order to enormously attenuate the disturbances caused by RWs, the vibration isolation system is installed between each RW and a satellite bus. The dynamic model of integrated satellite system with RWs and the new vibration isolation system is constructed. The frequency domain characteristics of the vibration isolation system are described. Using the reasonable parameters of the vibration isolation system, the performance of it on the satellite is testified by numerical simulations. These efforts could be viewed as the basis of future researches on the vibration isolation platform with multiple tuned mass dampers designing.