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Short communication

The influence of flywheel micro vibration on space camera and vibration suppression

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ABSTRACT

Studied the impact of flywheel micro vibration on a high resolution optical satellite that space-borne integrated. By testing the flywheel micro vibration with six-component test bench, the flywheel disturbance data is acquired. The finite element model of the satellite was established and the unit force/torque were applied at the flywheel mounting position to obtain the micro vibration data of the camera. Integrated analysis of the data of the two parts showed that the influence of flywheel micro vibration on the camera is mainly concentrated around 60–80 Hz and 170–230 Hz, the largest angular displacement of the secondary mirror along the optical axis direction is 0.04″ and the maximum angular displacement vertical to optical axis is 0.032″. After the design and installation of vibration isolator, the maximum angular displacement of the secondary mirror is 0.011″, the decay rate of root mean square value of the angular displacement is more than 50% and the maximum is 96.78%. The whole satellite was suspended to simulate the boundary condition on orbit; the imaging experiment results show that the image motion caused by the flywheel micro vibrationis less than 0.1 pixel after installing the vibration isolator.

0. Introductions

With the rapid development of space technology, the space camera with large aperture and high resolution has played an increasingly important role in the field of civil, commercial, military, and astronomy [1]. However, the micro vibration generated by the spacecraft, such as the flywheel, the control moment gyroscope and the focusing mechanism, would significantly reduce the imaging quality of the space camera [2,3]. The micro vibration of spacecraft is complex with small amplitude, wide spectrum, which is difficult tobe measure and suppress [4,5]. Moreover, large space camera technology involves many disciplines, the existing micro vibration analysis technology and suppression measures are difficult to meet the needs of its development. So the research of the micro vibration analysis method and suppression technology is very important for the development of high resolution optical satellite.

NASA began to study the reasons for the micro vibration in 1980s, and found that the active parts of the satellite will cause micro vibration [6]. A comprehensive summary of the disturbance source of micro vibration generated on spacecraft was made by Eyerman from in 1990, the source of the disturbance is divided into two categories: the internal disturbance of

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the spacecraft and the disturbance caused by the external environment [7]. Laskin and Martin point out that the biggest disturbance source on the spacecraft is the Reaction Wheel Assembly (RAW) and Control Moment Gyroscope (CMG) [8]. According to the vibration test data of the reaction wheel on the Hubble Space Telescope, the empirical model is established in Ref. [9]. Masterson and Miller from MIT, using Matlab developed a set of tools to extract the relevant parameters of the empirical model from the micro vibration test date, which can predict the disturbance spectrum generated by RWA or CMG under different conditions [10]. The micro vibration response of the RWA or CMG, in a remote sensing satellite which was suspended, is measured; the result shows that the effect of the noise on the test results is small under this condition [11].

Generally, satellite platform and space camera were developed by different departments, the whole process involves a number of research units, which makes the study of the whole satellite vibration is more difficult. Aiming at an integrated design of high resolution optical satellite, this paper focuses on the problem of micro vibration of the flywheel. By testing the flywheel micro vibration with six-component test bench, the flywheel disturbance data is acquired. The finite element model of the satellite was established and the unit force/torque were applied at the flywheel mounting position to obtain the micro vibration data of the camera. Then the results of the two parts are integrated to obtain the disturbance characteristics of the micro vibration. Based on this, the flywheel vibration isolator is designed, and the performance of the flywheel is tested. Finally, the whole satellite was suspended to simulate the boundary condition on orbit, the results of imaging test show that the micro vibration of the flywheel has little effect on the image after installing the vibration isolator.

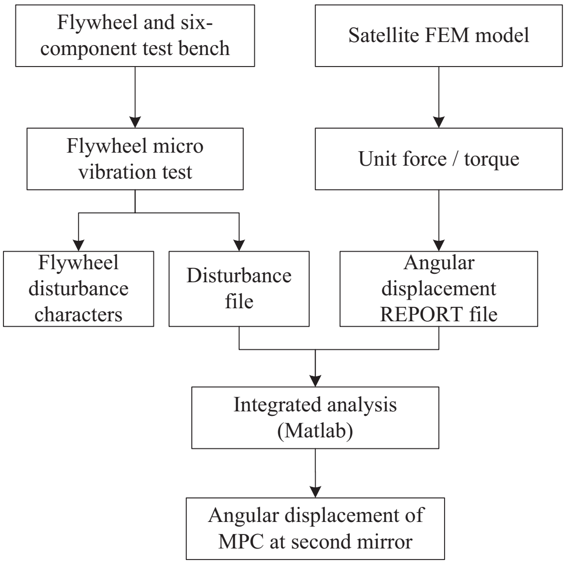

Fig. 1. Flow chart of the influence of micro vibration on the camera.

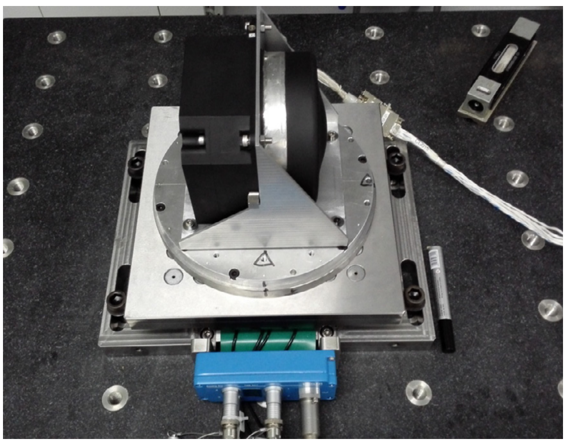

Fig. 2. Test site of flywheel disturbance.