인공위성 카메라 주반사경을 위한 플렉셔 마운트 개발
Bipod Flexure Mount for the Primary Mirror in a Satellite Telescope

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1. Introduction

The performance of optical mirrors, such as those employed in satellite telescopes, may be severely degraded by an inappropriate mounting configuration. The general design objective and philosophy of an optical mirror mount are introduced by Chin [1]. The concepts for a successful mounting should minimize optical distortions and provide a simple means of alignment. A kinematic mount is an ideal support constraining three orthogonal axes without redundancy. However, the point contact desirable for a kinematic support is not feasible in environmentally challenged systems. Instead, a semi-kinematic mount with a finite contact area is usually adopted to disperse local stresses. Flexure mounting may be regarded as a semi-kinematic design. A flexure is a monolithic structure providing elastic motions in a predefined way. The benefits of using flexures include lack of the hysteresis and the friction effects inherent in semi-kinematic mounts. Also, maintenance is unnecessary and fabrication has become common practice with electrical discharge machining. A mirror mount flexure is not intended for linear or precise motions. Different from the flexure hinges used in actuator mechanism, a mirror mount flexure minimizes optical surface distortions and maintains optical alignment under operation or transport. Kinematic principles determine the location and the direction of a mounting flexure. The line of action of the flexure should pass through the mirror’s center of gravity. Compliance should be provided to athermalize the mirror and mounting flexures. For example, radial compliance should be added in an axisymmetric mirror element. Tangential compliance is also required to prevent assembly stress from propagating toward the mirror surface [2].

Flexure mounts can be categorized according to the type of flexure element. Simple blade flexures are usually used as tangential edge supports for relatively small axisymmetric mirrors [2]. A bipod flexure, which is the most common support type, generally gives better results in terms of optical performances [3, 4]. Conventional bipod flexures are made monolithically and are used as lateral supports. The angle of the bipod flexure or the height of the apex formed by the bipod should be aligned in such a way that the mirror's surface distortion due to gravity can be minimized. However, the fabrication tolerance of a glass-ceramic mirror is relatively high compared with a metallic substrate due to the inherent manufacturing limitation. Slight deviations of the mirror's dimensions result in a change of mass center and inertial moments. And combined with fabrication and assembly errors of the bipod flexures, the mirror's surface distortion cannot be minimized as expected. If the deviation is too large or unacceptable, a new set of bipod flexures should be made to compensate for mirror's fabrication errors. This procedure is, however, time-consuming and costly. Also it is risky to remove structural adhesives coupling the mirror and bipod flexures and to replace with a new flexures.

This paper describes a new bipod flexures having mechanical shims to adjust gravitational distortions at the mirror surface. Even when there are inevitable fabrication and assembly errors deviating from nominal design values, the mirror's gravitational distortion can be adjusted and minimized by replacing mechanical shims with a suitable thickness. Also gluing the mirror with flexures is once and for all, which is desirable for mirror's safety. Section 2 describes the principles and configurations of the new bipod flexure system. Section 3 explains the performance of the flexure with theoretical and experimental results. Section 4 shows the results of vibration tests and verifies its application in space optical system. Section 5 concludes this paper.

2. Principle

The configuration of bipod flexures mounting a primary mirror is shown in Fig.1. The mirror is fabricated having lightweight pockets at the back surface. It has three square bosses extruded at the mirror's rim for flexure mounting. The flexure is coupled with the mirror by using an epoxy adhesive. Contrary to the monolithic bipod flexures, this flexure has three components. Flexure A is fixed onto the mirror's boss permanently by using an adhesive. The flexure B is fastened to the flexure A with threaded bolts and locating pins. A shim is located in the middle between flexure A and flexure B and can be changed with a suitable thickness to adjust the mirror's distortion due to gravity. The apex of the triangle formed by a bipod flexure should point to the mass center of the mirror or equivalently shear center of the mirror in order to minimize the surface distortions due to gravity. A small amount of misalignment makes the mirror surfaces have astigmatic wavefront error.

3. Conclusions

We presented a new mirror mounting technique applicable to the primary mirror in a space telescope. Conventional bipod flexures for mounting mirror bosses are changed to have mechanical shims to adjust gravitational distortions at the mirror surface. Analytical results using finite element methods are compared with experimental results from an optical interferometer. Vibration tests qualified their use in space applications.

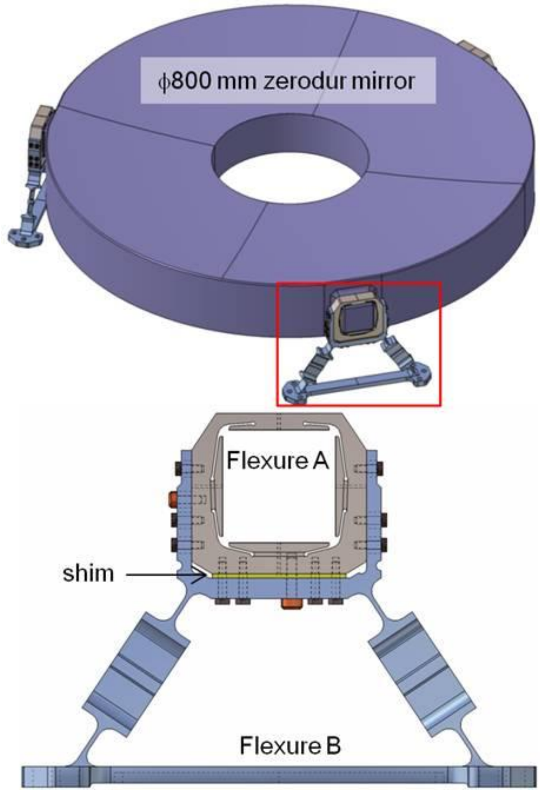

Fig. 1 ϕ800 zerodur mirror mounted on bipod flexures is shown. The bipod flexure is composed of flexure A, flexure B and a shim. The shim can be changed easily to adjust mirror surface distortions.

References

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