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OPTI 521-Optomechanical Engineering
Report 1 – Synopsis of Technical Report
Chapter 8.3 *Semikinematic Mounting for Small Mirrors*
Opto-Mechanical Systems Design by P. R. Yoder, 2006
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Abstract
Chapter 8.3 *Semikinematic Mounting for Small Mirrors* has general information, concrete examples, and useful drawings about how to properly mount small nonmetallic mirrors. Although subjects of this chapter have been around for a while, they are still ubiquitous in the field of optical engineering. The examples in this chapter can be used as a starting point in by any opto-mech engineer designing a sturdy, robust mirror mount. Knowing a few basic concepts of mirror mounting can be very helpful and this chapter serves as a great resource on the subject. The examples from this chapter are listed below.

1. The Spring Clip Mount
2. Solid Clip Mount
3. Convex Mirror Retainer Mount
4. Concave Mirror Retainer Mount
5. Continuous Flange Mount
6. Cylindrical Pad V-mount

Synopsis
A notable prelude to Chapter 8.3 is in chapter 8 *Design and Mounting Small, Nonmetallic Mirrors, Gratings, and Pellicles* where it defines 'small' in this context. It defines a 'small' mirror as weighing less than 56 lbs (just the substrate). This upper limit corresponds to a 20 inch diameter 2.2 inch thickness mirror of typical substrate material. This is in contrast to *Introduction to Opto-mechanical Design* by Yukobratovich, 2007 which defines a small mirror as being less than 150 mm (5.9 inch) diameter.

Chapter 8.3 begins by instructing the opto-mech designer to treat the mirror as a flexible plate (not very rigid). This is because the amount of mounting deformation that is tolerable is almost always very tight in optical engineering. The forces that must be considered in mirror mounting (same as mounting all types of optics) is mixed into a list of other factors that must be considered.

The chapter gives the equations for preload, deflection, stress, and torque calculations, but only the sections views of each example are included in this synopsis.

1. The Spring Clip Mount
The chapter goes strait into an example of a simple effective mount that I will call the Spring Clip Mount (see Figure 1). This mount uses 3 spring clips to clamp the mirror to 3 flat, coplanar surfaces (pads) of the mount. This design directly constrains 3 DOFs: 1 translation and 2 angular. The other DOFs are not directly constrained but are held by friction, which is acceptable if the mirror is to be used in stable environment. Also, optical performance is usually insensitive to these unconstrained DOFs for a flat mirror.

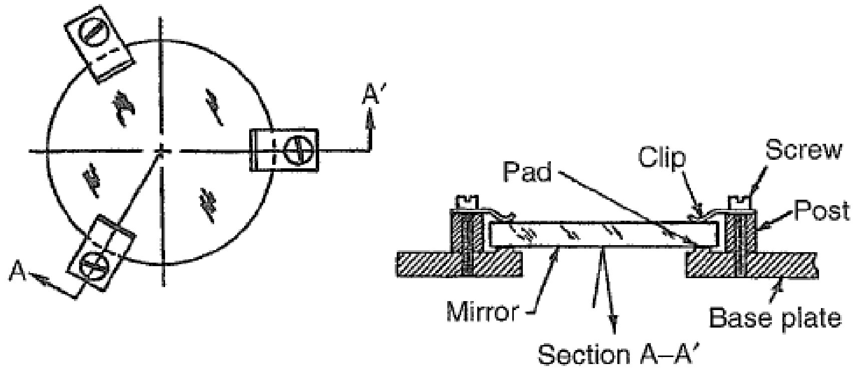

Figure 1. The Spring Clip Mount

First one has to calculate the required preload force of the clips to the mirror. The required preload is a function of the weight of the mirror, the sum of all external forces, and the safety factor. The details of this calculation are not very adequate, but once the preload has been determined, one can continue to calculate how to make the clips exert this force.

Once we know the required preload, we calculate the amount of deflection of the spring clip in order to produce this preload. This deflection is a function of the preload, the geometry of the clip, the number of clips, and Young's Modulus of the clip material.

Now we must check if the stress induced by this deflection is less than the material strength. Note that increasing the number of clips reduced the preload and stress of each clip, but increases the number of required flat, coplanar pads. A single pad that is not perfectly flat or coplanar will deform the optic, inhibiting optical performance.

Then we just design the post height to be this deflection distance less than the mirror thickness (if the clip were flat). So when we tighten the screw the base of the clip will sit a bit lower than the mirror height causing the clip to bend and clamp the mirror into place.

2. Solid Clip Mount

Another common mirror mounting technique is the Solid Clip Mount (see Figure 2). This mount is similar to the Spring Clip Mount except the compliance is taken up by soft pads, instead of the clips. The pads may be made of neoprene. The book does not detail the calculation of the required pad deflection. A disadvantage of this mount is that the soft pad material may become stiffer over time.

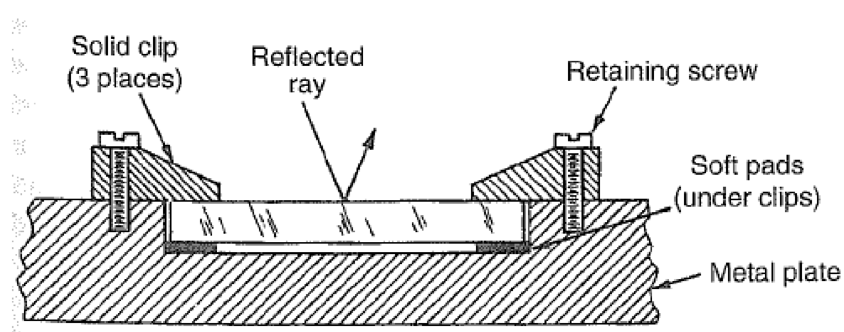

Figure 2. Solid Clip Mount

3. Convex Mirror Retainer Mount

Now the book leads into mounting curved mirrors using a retainer, a common lens mounting method. There is a practical limit on the mirror size to be mounting with a retainer because of the difficulty of manufacturing large retainers of sufficient quality. Figure 3 is an example of a convex spherical mirror retainer mount. This design uses a tangent interface shoulder in contact with the reflecting surface. The shoulder must have the same slope as the mirror at the contact (tangent interface). Tightening the retainer will center the mirror to the mechanical axis of the mount. This requires the retainer threads to have some slop in the mount threads so the retainer will align to the mirror once in contact. We are effectively constraining the 2 remaining translational DOFs left over from the previous clip mounts for flat mirrors. Long radius mirror will not self center so easily and may require radial locating pads. Once the required preload has been calculated, the corresponding torque of the retainer can be calculated.

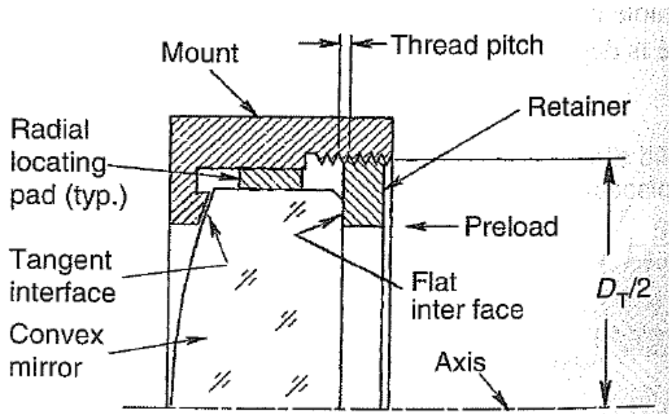

Figure 3. Convex Mirror Retainer Mount

4. Concave Mirror Retainer Mount

The same mounting technique can also be used on concave mirrors. If both surfaces of the mirror are curved, the mirror should be made with some flat section outside of the clear aperture for a tangent interface with the retainer. Again, the radial locating pads are only necessary for long radius mirrors.

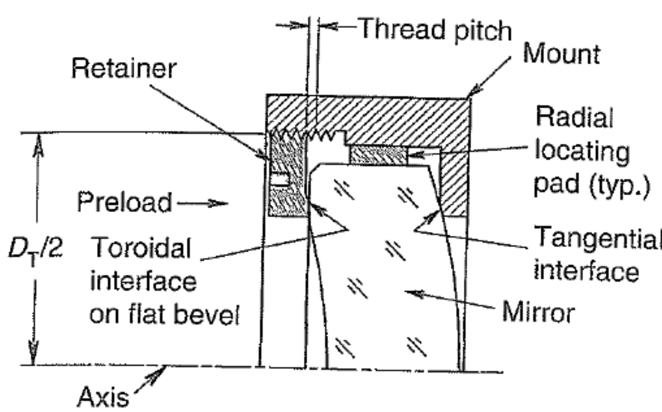

Figure 4. Concave Mirror Retainer Mount

5. Continuous Flange Mount

The next mount that is discussed is the Continuous Flange Mount. A section view of this mount (see Figure 5) may look the same as the Spring Clip Mount, but it's not. The flange is like a continuous clip that covers the entire outer rim of the mirror. This mount can have a much higher clamping force (preload), thus is better suited for larger mirrors or mirrors exposed to greater external forces (vibration, temperature change, etc.). Similar to the Spring Clip Mount, we calculate the required preload, then the corresponding flange deflection. Except the flange deflection is a bit more complicated than the spring clip deflection.

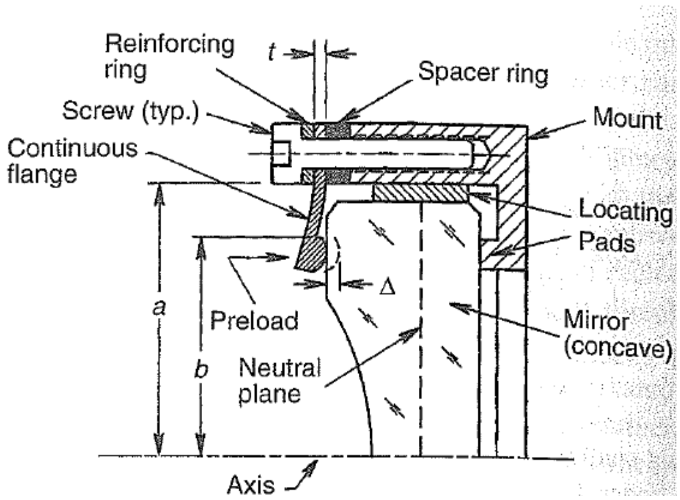

Figure 5. Continuous Flange Mount

An additional feature shown in this Mount is the spacer ring. This is just a simple ring, with holes for screws that can be used to tune the preload by varying the ring thickness. Because this part is simple, an engineer can make customized spacer rings to control the preload accounting for variations in thickness of as-manufactured mirrors, or changes in external forces from what was originally designed for.

6. Cylindrical Pad V-mount

The next example is the Cylindrical Pad V-mount (see figure 6). This mount is very simple to remove and replace the mirror but can only be used for small mirrors. The mirror is preloaded against the 2 nylon cylindrical pads with the nylon setscrew. This constrains 2 translational DOFs. The other translational DOF and all 3 angular DOFs are indirectly constrained by friction with the pads and setscrew. The shoulder is not so much for structural support but more to hold the mirror in place before the setscrew takes hold. Thermal deformations will be taken up by radial compliance of the setscrew. A safety feature built into this mount is the retainer ring. This only serves as a secondary support to save the mirror in case the primary support fails. An equivalent safety feature should be used with expensive mirrors in simple mounts like this.

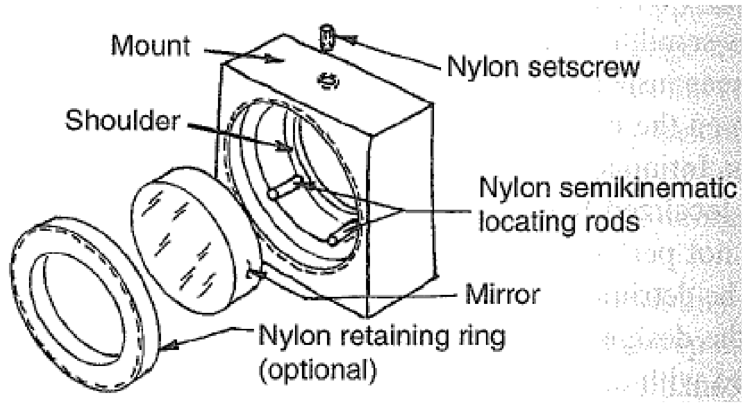

Figure 6. Cylindrical Pad V-mount

Note on the location of the clamp force

The chapter ends with a note on the location of the clamp force (preload) relative to the supports. Apply the preload perpendicular to the mirror surface and in-line with the supports as shown in Figure 7. This maintains a pure compression preload, as opposed to applying a bending moment into the mirror. Smaller mirrors, with low diameter to thickness aspect ratio, may be so stiff that this is not an issue.

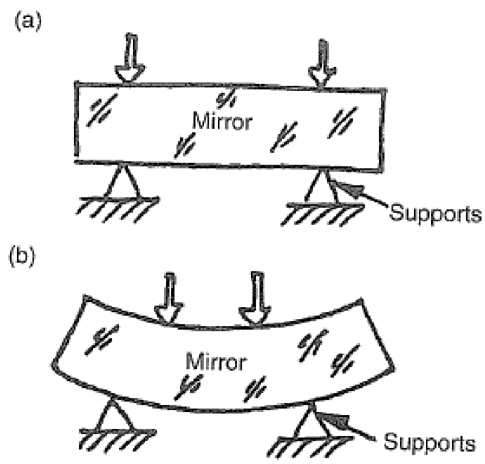

Figure 7. Location of Clamp Force Relative to Support

Conclusion

This chapter is a great introduction to mirror mounting. It uses specific examples with very clear and instructive section views. The chapter does not have the following: adjustments, numerical examples, explain external forces for preload calc, distinguish between horizontal axis and vertical axis mirrors, develop the flexure mount concept, show bracket part of the mount that connects to the table or higher level assembly. Most of this information can be found in other chapters of Yoder's book. Compared to *Introduction to Opto-Mechanical Design* by Vukobratovich 2003, this chapter gives more examples but fewer rules-of-thumb. Once again, this chapter serves as a great resource on the subject of Mirror Mounting.