ANALYSIS OF MIRROR DISTORTION DUE TO TORQUES ON THE MOUNTING FEET

Spartan IR Camera for the SOAR Telescope

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If the surface to which the mirrors are being bolted is not perfectly flat, a torque will be exerted on the feet of the mirror possibly distorting its reflective surface.

1 Purpose

The purpose is to decide how tight the surface finish tolerances of the mirror mounts must be in order to avoid exceeding surface distortion requirements.

2 Procedure

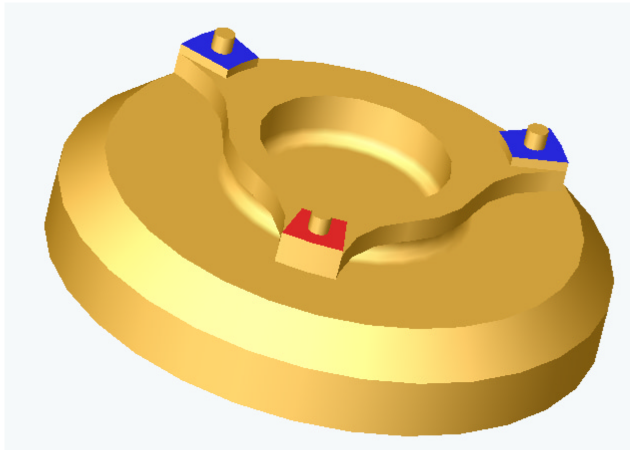
2.1 Requirements

The reflective surfaces of the mirrors are being finished smooth to $\lambda/8$. The distortion of the reflective surface due to the smoothness of the mount should be less than this.

2.2 General Description

Being bolted to an uneven surface results in a torque on the feet of the mirror. The magnitude of the effect of torque on surface integrity is unknown. Assuming a milled surface can be made level to ½ mil over 1" or an angle of 500 μrad., it needs to be determined whether further finishing is needed.

2.3 Test Case



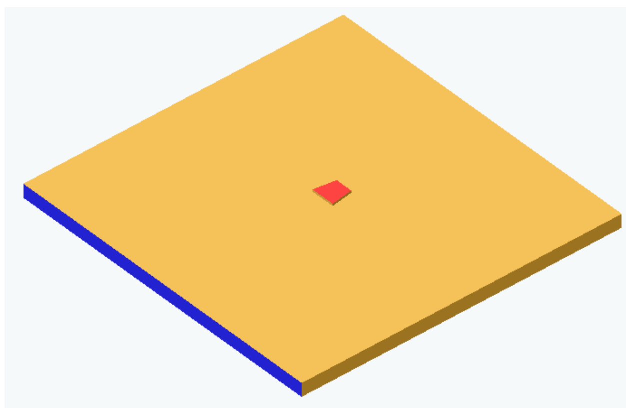


Figure 1: The flat mirror and the ¼" plate. Constrained surfaces are shown in blue while surfaces under a torque are red. The collimator was constrained and torqued in the same was as the flat mirror.

For both the flat mirror and the 238 mm collimator, two of the three feet were solidly constrained while a torque of 1 N-m was applied to the third foot. Both the rotation of the foot and the distortion of the mirror face were measured. In addition, the same torque was applied to a ¼" aluminum plate over an area similar to that of the mirror foot and rotation measured.

3 Results

3.1 Method

In order to determine the maximum allowable torque on the feet and thus the required smoothness of the mounting surface, the applied torque needed to be scaled based on the total angle of rotation.

- Let θ_f and θ_p be the angles of rotation of the mirror foot and the plate respectively.
- Let α be the angle of roughness of the mounting surface.
- Let β_o be the distortion of the mirror face when the foot is torqued.
- The scaled surface distortion is then:

$$\beta_{scaled} = \beta_o [\alpha / (\theta_f + \theta_p)]$$

The required surface tolerance can then be calculated by scaling the original assumed finish tolerance (500 μrad in this case) by the ratio of the required distortion to the scaled distortion.

3.2 Flat Mirror

Rotation of Mirror Foot (θ_f)	Rotation of Plate (θ_p)	Assumed Finish Tolerance	Surface Distortion (β_o)	Scaled Surface Distortion (β_{scaled})
2220 μrad	360 μrad	500 μrad	1 μ	0.2 μ

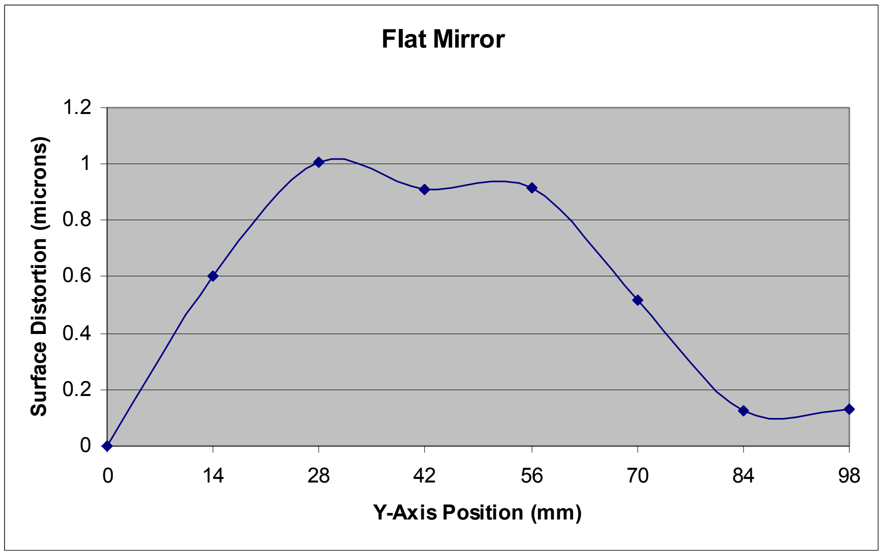


Figure 2 Displacement perpendicular to the face of the mirror was measured at evenly spaced points across the surface of the mirror (along the y-axis). The general slope was then removed in order to show only irregularities in the surface caused be distortion of the mirror. The foot being torqued is located close to the 75 mm mark.

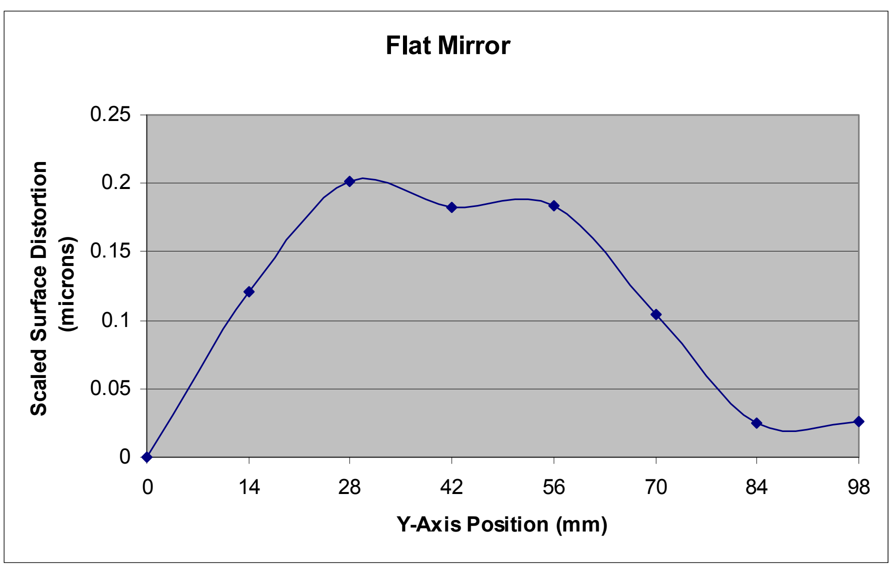


Figure 3 The results shown above in *Figure 2* were then scaled using the equation from 3.1. The maximum scaled distortion is 0.2 μ.

3.3 f/12 Collimator

Rotation of Mirror Foot (θ_f)	Rotation of Plate (θ_p)	Assumed Finish Tolerance	Surface Distortion (β_o)	Scaled Surface Distortion (β_{scaled})
718 µrad	360 µrad	500 µrad	0.7 µ	0.3 µ

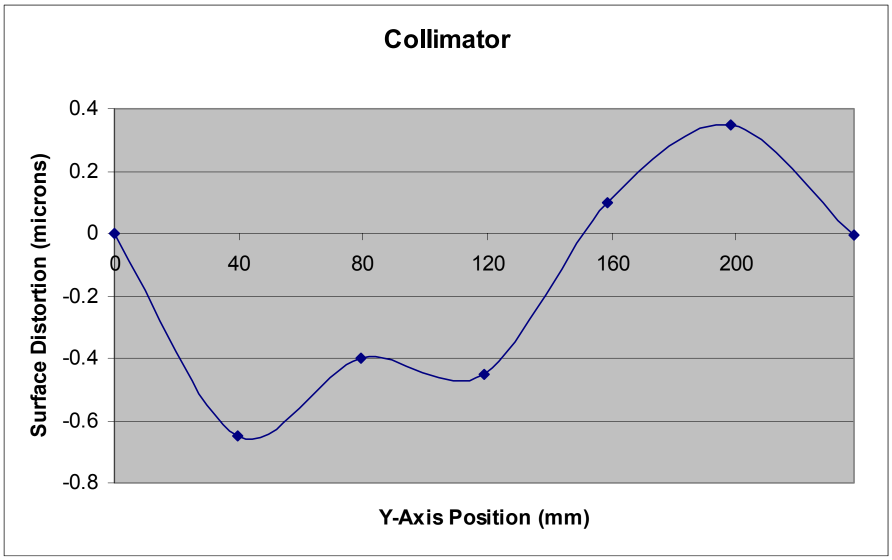


Figure 4 Displacement perpendicular to the face of the mirror was measured at evenly spaced points across the surface of the mirror (along the y-axis). The general slope was then removed in order to show only irregularities in the surface caused be distortion of the mirror. The foot being torqued is located close to the 35 mm mark.

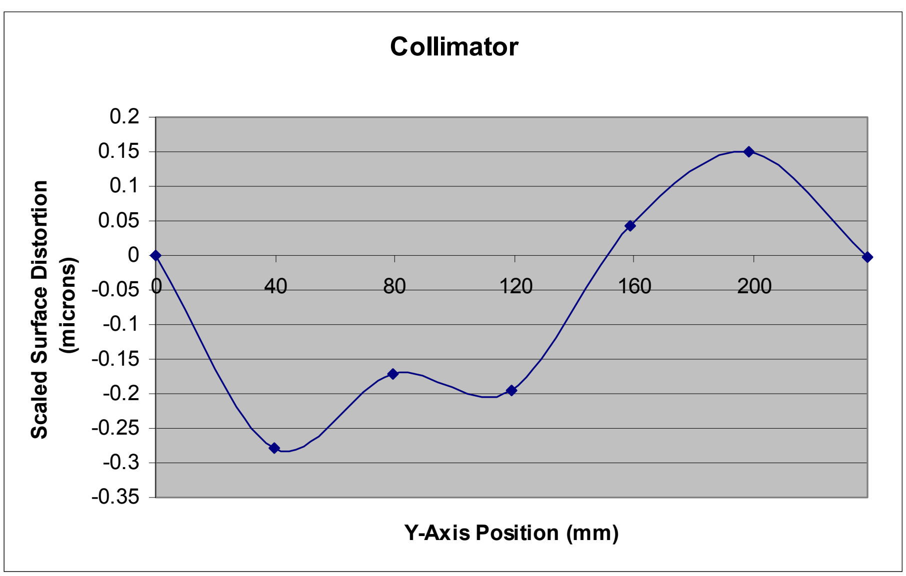


Figure 5 The results shown above in *Figure 4* were then scaled using the equation from 3.1. The maximum scaled distortion is about 0.3 µ.

4 Conclusions

The goal is to keep the distortion of the mirror faces below $\lambda/8$ in order to avoid it being the limiting factor. To safely achieve this, the slopes on the surfaces to which the flat mirrors and the collimators are mounted must be less than 0.1 mrad or flat to 1/8 mil over 1”.