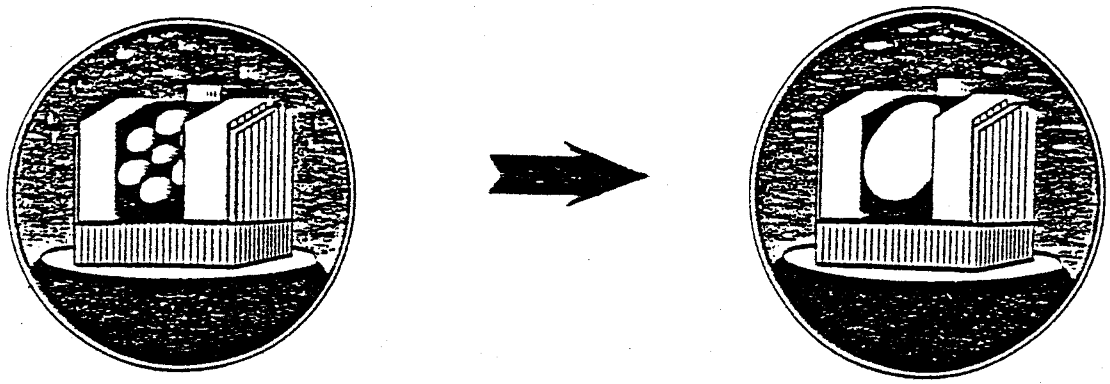
6.5 METER TELESCOPE



MMT Conversion Internal Technical Memorandum #95-1

Upper Hardpoint Flexure Analysis

Shawn Callahan and James Catone

August 31, 1995

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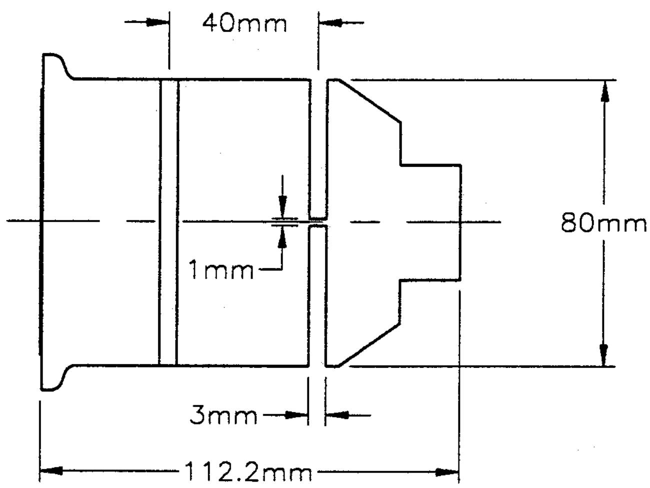
Introduction

Flexures are placed on both ends of the hardpoints to allow for angular deflection caused by translation of the mirror in the mirror cell. The moment required to bend the flexures produces a moment on the back of the mirror. This technical memo describes the analysis and experimental measurements of the bending stiffness of the flexures and calculates the magnitude of the moments applied to the back of the mirror. According to John Hill's LBT Project technical memo UA-94-02, the maximum acceptable moment applied to the back of the mirror is 8,000 N-mm.



Original Design

Currently, the hardpoint flexure design, MMT0310 / Studio Technico Tomelleri MMT.001.011.0, consists of square slots cut into a 112.2mm long cylinder, forming a 1mm thick by 3mm wide flexure. Two of these flexures are cut into the cylinder 40mm apart at right angles to each other, allowing angular deflection in any direction.

The hardpoint flexures must be able to support axial loading with sufficient axial stiffness as the telescope rotates from horizon to zenith pointing angles. They must also be reliable for an extended period of time as a flexure failure might cause the mirror support system to fail.

By replacing the square slot geometry of the flexures with a rounded slot, we can reduce the stress within the flexure while maintaining the required axial and bending stiffness.

Analytical Results

A two dimensional FEA model of the flexure was created to compare the relative stress concentration factor, axial stiffness, and bending stiffness of the new model with that of the original design.

The stress concentration factor is a result of the geometry of the material, i.e. sharp internal corners, holes through the material, and notches increase the local stress. The local stresses at these geometric anomalies are considerably greater than the average stress within the material and often the cause of fatigue failure. Analysis shows that the actual stress in the new flexure will be at least five times less than the original flexure.

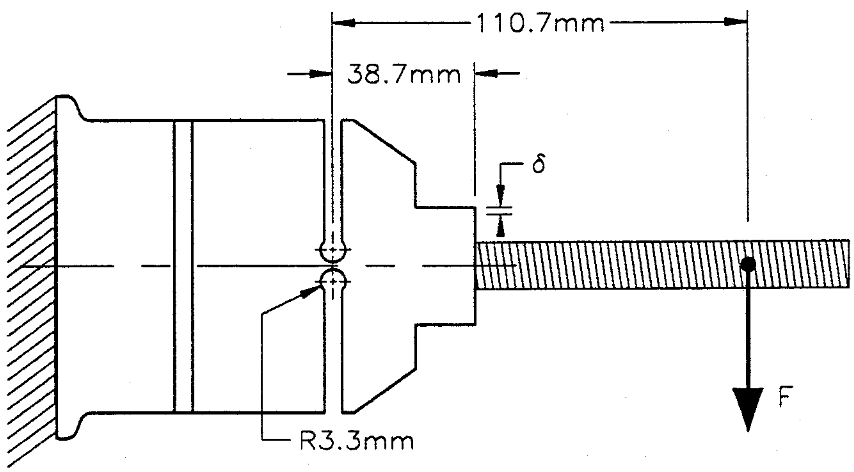
The new design has a 20% higher axial stiffness than the original design and the bending stiffness is 35% higher.

Experimental Results

Since the hardpoint flexure prototype was made out of mild steel, only small deflections were analyzed to prevent permanent deformations. The final flexures will be made out of a high strength steel.

The bending stiffness of the flexures, measured using the experimental setup shown below, is $0.6\times10^6\ {}^{\text{N-mm}}/_{\text{rad}}$. The maximum translation of the mirror in the telescope cell of 3mm causes an angular deflection of the hardpoints of 0.004 radians. Therefore the maximum moment applied by the flexures to the back of the mirror is 2400 N-mm.

Experimental Setup



New Flexure

With the base of the flexure rigidly fixed, a force, F, was applied 110.7mm from the upper flexure, producing an angular deflection. The linear deflection was then measured 38.7mm from the upper flexure and the angular deflection, $\theta = \tan^{-1}({}^{\delta}/_{38.7})$, calculated.

The bending stiffness was calculated by dividing the applied moment, 110.7*F, by the angular deflection, θ, produced.

The maximum moment applied to the mirror by the flexure was calculated by multiplying the bending stiffness and the maximum allowable angular deflection.

Conclusion

As compared to the original design, the new flexure design has lower stress for a given load and therefore has a greater resistance to fatigue failure. The axial stiffness of the new design is higher and the bending stiffness does not adversely affect the optical figure of the mirror.