Deflection-Compensating Beam for Use Inside a Cylinder

Deflections are minimized by combined effects of the beam and cylinder shapes.

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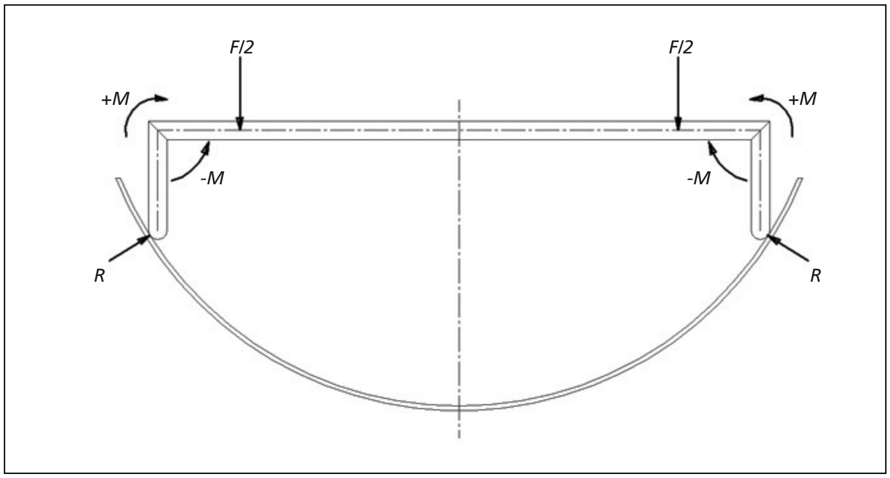
A design concept for a beam for a specific application permits variations and options for satisfying competing requirements to minimize certain deflections under load and to minimize the weight of the beam. In the specific application, the beam is required to serve as a motion-controlled structure for supporting a mirror for optical testing in the lower third portion of a horizontal, cylindrical vacuum chamber. The cylindrical shape of the chamber is fortuitous in that it can be (and is) utilized as an essential element of the deflection-minimizing design concept.

The beam is, more precisely, a tablelike structure comprising a nominally flat, horizontal portion with vertical legs at its ends (see figure). The weights of the beam and whatever components it supports are reacted by the contact forces between the lower ends of the legs and the inner cylindrical chamber wall. Whereas the bending moments arising from the weights contribute to a beam deflection that is concave (as viewed from above) with its lowest point at midlength, the bending moments generated by the contact forces acting on the legs contribute to a beam deflection that is convex (as viewed from above) with its highest point at midlength. In addition, the bending of the legs in response to the weights causes the lower ends of the legs to slide downward on the cylindrical wall.

By taking the standard beam-deflection equations, combining them with the geometric relationships among the legs and the horizontal portion of the beam, and treating the sliding as a component of deflection, it is possible to write an equation for the net vertical deflection as a function of the load and of position along the beam:



In this free-body diagram of a **Deflection-Compensating Beam**, *F* = applied force, *M* = resulting moment, and *R* = reaction force.

Total Deflection = (Deflection From Simple Support, Moment Load) + (Deflection From Simple Support, Twin Loads) + (Sliding at Wall)

The following is a summary of major conclusions drawn from the verbal characterization:

- The deflection at the point of application of a load cannot be made zero but it can be reduced, relative to the case of a simply supported beam of equal length.
- It is possible to obtain zero deflection at either the ends of the beam, the midlength point, or two points equidistant from the midlength point.
- The locations of the zero-deflection points are independent of the magnitude of the applied load. Moreover, if the beam and the legs are made of the same material and their cross sections are of the same size and shape, then the locations of the zero-deflection points are independent of the material and the cross sections.
- The maximum stresses occur at the ends of the horizontal portion of the beam.

Yet another advantage of the design concept arises from a fundamental geometric property. Just as a table having three legs of possibly unequal length can always rest on a horizontal surface without wobbling, a table having four legs of possibly unequal length can always rest on a cylindrical surface without wobbling. Hence, one can always be assured of realizing the desired geometry of contact between the beam and the cylindrical wall, and tolerances on leg lengths can be large. Hence, further, the cost of fabrication can be less than it would be if it were necessary to adhere to tight tolerances to ensure the desired geometry of contact.

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Four-Point-Latching Microactuator

Fabrication is simplified and susceptibility to jamming greatly reduced.

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Figure 1 depicts an experimental inchworm-type linear microactuator. This microactuator is a successor to the one described in "MEMS-Based Piezoelectric/Electrostatic Inchworm Actuator" (NPO-30672), *NASA Tech Briefs*, Vol. 27, No. 6 (June 2003), page 68. Both actuators are based on the principle of using a piezoelectric transducer (PZT) operated in alternation with electrostatically actuated clutches to cause a slider to move in small increments. However, the design of the present actuator incorporates several improvements over that of the previous one. The most readily apparent improvement