INTRODUCTION TO FLEXURE HINGES

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A flexure hinge is a mechanical member that is very compliant in bending about one axis but very rigid about the cross axes. Applications include use as friction-free pivots in sensors, transfer and multiplying linkages, indicators, and actuators.

Accurate measurements are the fundamental basis of experimental science. Sensors such as accelerometers, pressure transducers, and balance scales usually include compliant mechanisms that transmit the loads and deflections to detectors that produce electrical outputs. Flexure hinges are widely used in high precision applications where the sensors are designed to operate with low full-scale stresses and small deflections. Designers of compliant mechanisms must analyze and compute the angular and linear deflections for all types of applied loads. Sixty years ago, Paros and Weisbord derived exact analytical solutions as well as simplified design equations for circular flexure hinges [1]. This work was expanded in [2] to include closed form and finite element solutions for non-circular flexures, two-axis pivots, as well as complex compliant mechanisms.

Some of the most demanding applications employ sensor designs with flexure hinges that pivotally transmit forces to quartz crystal load-sensitive resonators. Indeed, the development of the aforementioned resonator technology has been contemporaneous with flexure hinge design and analysis for the last six decades. The inherently-digital quartz resonator sensors have resolution of parts-per-billion, excellent repeatability, low hysteresis, insensitivity to environmental errors, and good long-term stability [3]. The flexure hinge suspensions must not degrade overall sensor performance. The pivots must be very compliant so that almost all of the loads are applied to the quartz resonators. The need for high compliance can result in a flexure thickness as small as 10 micrometers. At the same time, the flexure can be subjected to loads of many kilograms. The tight constraints on resonator movement help to optimize flexure performance. The full-scale deflection of the load-sensitive resonators is about 2 micrometers with nano-resolution sensitivity on the order of a few femtometers.

The foregoing example shows that flexure hinges must be carefully analyzed, designed, and integrated as a critical element of sensor performance.

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