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# Two-axis flexure hinges with axially-collocated and symmetric notches

Nicolae Lobontiu *, Ephrahim Garcia

*Sibley School of Mechanical and Aerospace Engineering, Cornell University, 258 Upson Hall, Ithaca, NY 14850, USA*

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**Abstract**

The paper introduces a new class of two-axis flexure hinges with axially-collocated and symmetric notches as an alternative to the existing flexure designs with serially-disposed notches. A generic formulation is developed in terms of the geometric curves defining the two notches which includes assessing the capacity of rotation, precision of rotation, sensitivity to parasitic effects, stress values, motion efficiency and shearing effects by means of compliance factors. Closed-form compliance equations are derived for a two-axis flexure hinge that is defined by two non-identical parabolic profiles. The analytical model predictions are confirmed by finite element data. A numerical comparison is made of the parabolic flexure with a constant rectangular cross-section flexure hinge in terms of several performance criteria.


*Keywords:* Flexure hinge; Compliant mechanisms; Two-axis; Collocation; Parabolic

## 1. Introduction

A compliant mechanism contains at least one link that is designed to be elastically deformable. In most cases the flexible link connects two adjacent rigid members and is usually sensitive to bending, which leads to being called flexure hinge, flexural pivot or simply, flexure. The flexure hinge is actually an elastically-flexible, slender part between two rigid members undergoing relative limited rotation in a mechanism (called 'compliant', due to the presence of at least one flexure hinge) that is supposed to achieve a specific task. The compliant mechanisms gain their mobility by transforming an input form of energy (mechanical, electric, thermal, magnetic, etc.) into output motion. The flexure hinge is monolithic with the rest of the mechanism for the vast majority of applications and this is the source of its advantages over classical rotation joints.

The benefits provided by flexure hinges include lack of friction losses, no need of lubrication, no hysteresis, compactness, ease of fabrication, no maintenance necessary, and no repair for the flexure hinges that are monolithic with their compliant mechanism since the mechanism will operate until a flexure will fail because of fatigue or overloading.

There are however certain drawbacks in flexure-based compliant mechanisms and one of them regards the inherent trait of the flexure hinges of providing relatively low rotation levels because of stress limitations. Also, the rotation is not pure because a flexure hinge is sensitive to axial loading, shearing and torsion, in addition to bending. Unlike classical rotation joints that keep their center of rotation in a fixed position, the 'rotation center' of a flexure hinge (this role is generally attributed to its midpoint) is not fixed during the relative rotation produced by the flexure as it displaces under the action of the combined load. Another disadvantage is that flexure hinges are temperature-sensitive and therefore thermal changes will modify their physical dimensions and, consequently, the compliance/stiffness properties, which will affect the motion precision and repeatability.

* Corresponding author.
*E-mail address:* nl73@cornell.edu (N. Lobontiu).

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