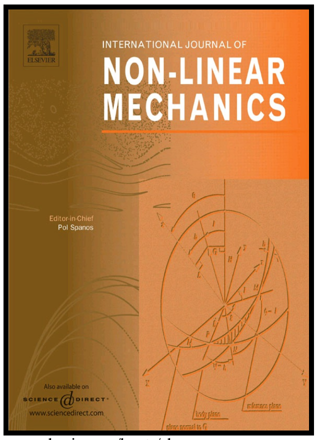
Author's Accepted Manuscript



www.elsevier.com/locate/nlm

Nonlinear Kinetostatic Modeling of Double-Tensural Fully-Compliant Bistable Mechanisms

Qi Han, Xinbo Huang, Xiaodong Shao

PII: S0020-7462(16)30306-7
DOI: http://dx.doi.org/10.1016/j.ijnonlinmec.2017.04.020
Reference: NLM2840

To appear in: *International Journal of Non-Linear Mechanics*

Received date: 8 November 2016
Revised date: 7 March 2017
Accepted date: 11 April 2017

Cite this article as: Qi Han, Xinbo Huang and Xiaodong Shao, Nonlinea Kinetostatic Modeling of Double-Tensural Fully-Compliant Bistabl Mechanisms, *International Journal of Non-Linear Mechanics* http://dx.doi.org/10.1016/j.ijnonlinmec.2017.04.020

Nonlinear Kinetostatic Modeling of Double-Tensural Fully-Compliant Bistable Mechanisms

Qi Han[1], Xinbo Huang[1,2*] and Xiaodong Shao[1]

[1] School of Electro-Mechanical Engineering, Xidian University, Xi'an, Shaanxi 710071, China
[2] School of Electronic Information, Xi'an Polytechnic University, Xi'an, Shaanxi 710071, China

Abstract

In double-tensural fully compliant bistable mechanisms (DTBMs), all of the compliant segments are loaded in tension when deflected, thus the problems associated with buckling are avoided. Because the stiffening of the compliant segments due to tensile loads plays an important role in achieving the bistable behaviors, it is critical to capture the relevant geometric nonlinearities when modeling DTBMs. Based on the beam constraint model (BCM) and the chained beam constraint model (CBCM), two kinetostatic models are developed for DTBMs in this work: Model I models both of the tensural segments using BCM, while Model II models the shorter tensural segment using BCM and the longer tensural segment using CBCM with two BCM elements. The two models well predict the bistability and the kinetostatic behaviors of a DTBM as compared to the finite element results. Although Model II is a little more complicated than Model I, it improves the modeling accuracy, especially at the negative stiffness region of the kinetostatic curve.

1 Introduction

Compliant mechanisms can provide frictionless and backlashless motion because they achieve their motion out of the elastic deflections of their flexible members [1]. Compliant mechanisms can also produce various interesting kinetostatic behaviors that could be potentially useful in many applications. Bistability is one of these kinetostatic behaviors. A compliant mechanism that exhibits bistability is called a bistable mechanism, which can maintain two distinct positions (known as stable equilibrium positions) without external power input [2].

Many applications may benefit from bistable mechanisms, for example, Hansen et al. [3] and Zhao et al. [4] proposed to use fully compliant bistable mechanisms for nonvolatile shock detecting, Gomm et al. [5] demonstrated a partially compliant bistable microrelay that could be useful for telecommunications switching and hand-held devices, Pham and Wang [6] presented a constant-force bistable mechanism for force regulation and overload protection, Hafez et al. [7] utilized bistable mechanisms to realize self-transforming of reconfigurable robotic devices, Gerson et al. [8] used multiple bistable mechanisms connected in series to produce large displacement actuation, Pucheta et al. [9] designed a four-bar bistable mechanism for landing gear deployment and retraction, Andò et al. [10] used a bistable mechanism to improve the efficiency of vibration energy harvesting, Alqasimito et al. [11] employed linear bistable compliant mechanisms to build shape-morphing space frames, and Haghpanah et al. [12] used bistable elements to construct shape-reconfigurable metamaterials, to name a few. Bistable mechanisms have also been used to achieve statically balanced compliant mechanisms [13, 14] and devise compliant mechanisms with more than two stable equilibrium positions [15–21].

There are a variety of bistable mechanisms, for example, the Young bistable mechanisms [2], the compliant four-link bistable mechanisms [23–25], the compliant bistable Sarrus mechanisms [26], the rotary bistable mechanisms [27], and various translational bistable mechanisms [5, 28–33]. In most of the translational bistable mechanisms, snap-through buckled beams arranged in a reflection symmetric configuration

[1]Corresponding author: huangxinbo@xpu.edu.cn