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Title: Design of a Stiffness-Adjustable Compliant Linear-Motion Mechanism

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Design of a Stiffness-Adjustable Compliant Linear-Motion Mechanism

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Highlights

- A stiffness-adjustable compliant linear-motion mechanism (CLMM) is proposed by applying loads at the secondary stage of a paired double parallelogram (DP-DP).
- The pre-loaded parallelogram and loading spring are utilized to deal with the loading issues; and the redundant degree of freedom (DOF) is restricted to a certain extent.
- The parasitic motion of the primary stage is diminished by arranging the configuration symmetrically.
- A model capable of predicting the stiffness characteristics of the proposed CLMM is developed through an energy approach.

ABSTRACT

A stiffness-adjustable compliant linear-motion mechanism (CLMM) is desired in practical applications. In this paper loads are applied at the secondary stage of a paired double parallelogram (DP-DP) to adjust stiffness, based on the analysis of a combination of parallelograms. Pre-loaded parallelograms and loading springs are utilized to solve the loading problem in practical applications, and the redundant degree of freedom (DOF) is restricted to a certain extent. Meanwhile, the parasitic motion of the primary stage is diminished by arranging the configuration symmetrically. Furthermore, a model, capable of predicting stiffness characteristics, is developed through an energy approach based on the relation between applied forces and internal forces, and a Lagrange multiplier is exploited to deal with the constraints. Finally, the analytical model is verified by finite element analysis (FEA) and experiments, and the errors caused by parasitic motion are corrected for this analytical model.

Keywords: Compliant linear-motion mechanism; Parallelogram; Adjustable stiffness; Parasitic motion; Energy approach

1. Introduction

The compliant linear-motion mechanism (CLMM) has been extensively utilized in precision engineering such as microscribing process [1], precision robots [2], accelerator facilities [3], micro-displacement sensors [4] and force sensors [5], interferometers [6], and isotropic springs [7], because of its remarkable advantages of no backlash,