



A tubular dielectric elastomer actuator: Fabrication, characterization and active vibration isolation

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ABSTRACT

This contribution reviews the fabrication, characterization and active vibration isolation performance of a core-free rolled tubular dielectric elastomer (DE) actuator, which has been designed and developed by Danfoss PolyPower A/S. PolyPower DE material, PolyPower™, is produced in thin sheets of 80 µm thickness with corrugated metallic electrodes on both sides. Tubular actuators are manufactured by rolling the DE sheets in a cylindrical shape. The electromechanical characteristics of such actuators are modeled based on equilibrium pressure equation. The model is validated with experimental measurements from 3 actuators. The dynamic characteristics of three tubular actuators fabricated from the same batch of manufactured DE material are presented and compared to: (a) provide insight into the ability of the fabrication process to produce actuators with similar characteristics and (b) highlight the dominant dynamic characteristics of the core-free tubular actuator. It has been observed that all actuators have similar dynamic characteristics in a frequency range up to 1 kHz. A tubular actuator is then used to provide active vibration isolation (AVI) of a 250 g mass subject to shaker generated 'ground vibration'. An adaptive feedforward control approach is used to achieve this. The tubular actuator is shown to provide excellent isolation against harmonic vibratory disturbances with attenuation of the resulting 5 and 10 Hz harmonics being 66 and 23 dB, respectively. AVI against a narrow band vibratory disturbance with frequency content 2–8 Hz, produced an attenuation of 20 dB across the frequency band.

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1. Introduction

For decades both material scientists and engineers have sought to find an artificial equivalent of muscle for the development of new transducer technology. This is because muscles, simply by changing their length in response to nerve stimulation, can exert controlled amounts of force. In this search for an artificial equivalent of muscle, electroactive polymers (EAPs) have gained considerable attention. A specific class of EAP known as 'dielectric elastomers' have demonstrated most potential as muscle-like actuators because they can undergo large deformation, have a high energy density and a relatively fast response [1,2,4]. The deformation characteristics and response time of dielectric elastomers place them between piezoceramics and shape memory alloys. The basic structure of a dielectric elastomer (DE) comprises

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