Accurate Characterization of Fluidic Artificial Muscle Force Response for Improved Model Fidelity

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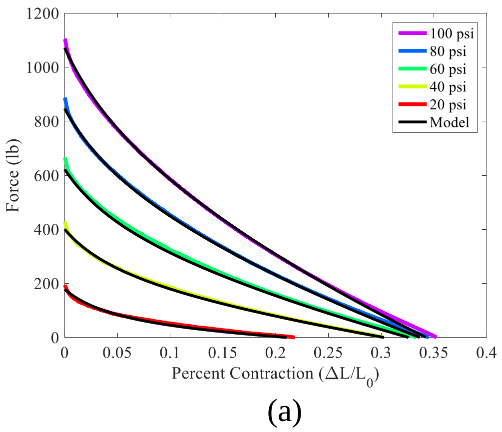
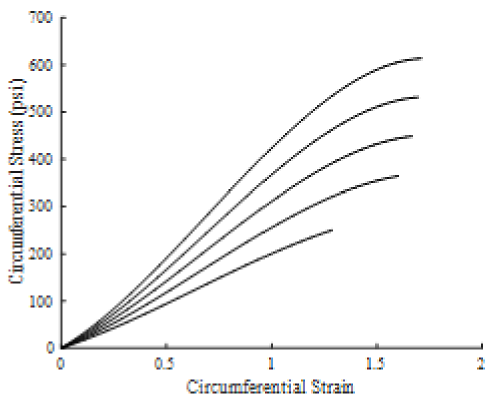
ABSTRACT

Obtaining an accurate characterization of a fluidic artificial muscle's (FAMs) force response is critical for fitted models to accurately represent experimental behavior. However, in many applications, experimental testing has revealed larger than expected length contractions, and lower than expected maximum force values. Through research characterizing FAMs with different working fluids, it was found that precise control of isobars for pressure-force-contraction response testing revealed that previous characterizations of FAMs had not accurately controlled pressure to represent truly isobaric tests. By creating pressure systems that provide accurate isobars for testing, it was found that the new characterization testing revealed larger maximum contractions, and reduced apparent hysteresis compared to previous testing without accurate pressure control. The results of the improved characterization testing are then applied to form a semi-mechanistic force response model of the FAM, and the affect of proper characterization on model results is analyzed. Fitting of the semi-mechanistic model using an optimization function enabled a good fit of the characterization data, and includes a constraint requiring a monotonically increasing stress-strain curve of the FAM's hyperelastic bladder that ensures a realistic resemblance of the bladder's nonlinear material response. Upon conclusion of this work, accurate FAM characterization will result in models that more accurately represent the force response of FAMs experienced in applications of FAMs. Additionally, new insights are made on the behavior of FAMs that can help inform how to improve the fidelity of the semi-mechanistic model.



(a)



(b)

Fig. 1 (a) 1 inch FAM characterization test data with overlaid fitted model and (b) resulting monotonic stress-strain curves for fitted model for each tested pressure isobar