Fluid-Driven Origami Actuators with Closed Volume - Engineering of Mathematically Inexistent Polyhedra

Abstract

Pneumatic drives are widely used in automation technology and for vibration decoupling, e.g. for suspension of sensible equipment. Additionally, an implementation of pneumatic drives in soft robots is discussed as these can be built to be inherently soft and of low stiffness. For the robust control of such soft actuators, the knowledge and/or the tailoring of the stiffness are prerequisites. Also, the possibility to further reduce stiffness of machine foundations could lead to interesting technical solutions emphasizing the need for geometry based shaping strategies for the stiffness of pneumatic drives.

In the scope of the presentation, the physical fundamentals of general pneumatic drives are introduced. This leads to the requirement of a pressure invariant, but stroke dependent volume for stiffness adjustment. While the demand for pressure independence of the geometry could be imagined to be fulfilled using a body of variable geometry and volume but with rigid walls, which would be comparable to Origami structures, the inexistence of such polyhedra is mathematically demonstrated. But, as technical systems allow for certain tolerances, this not necessarily implies, that such geometries and folding patterns are unrealizable. The presentation closes with the introduction of a possible solution consisting of a geometry with minimal deviation to a mathematical polyhedron but fulfilling all other requirements.

The presentation aims to initiate a discussion on how technical tolerances can be given greater importance in mathematics so that solutions that are only possible due to tolerances can be identified and those that will fail for this reason can be excluded at an early stage.

Biography

Olivier Reinertz received his diploma and his doctoral degree in mechanical engineering from RWTH Aachen University, Germany. He is currently Scientific Director at the Institute for Fluid Power Drives and Systems (ifas) at RWTH Aachen University. His research focuses on the model-based analysis of fluid power components and systems and the derivation and validation of innovative strategies for efficiency and performance optimization with an emphasis on compressed air and gas-powered systems.