Design and Analysis of a Hyperelastic Pneumatic Honeycomb Network Made of Ecoflex 00-35

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INTRODUCTION

Soft robotics allows for an increased flexibility and adaptability in the field of robotics, for example increased safety with regard to human-machine systems [1]. The Pneumatic Honeycomb Network (PHN) analyzed in this paper is a constitutive element in a new approach of dynamically sealing components. **Figure. 1** shows an example of such a PHN. Shape and volume of this biology-inspired hyper-elastic polymer structure can be changed by applying pneumatic pressure. Utilizing COMSOL®, the behavior analysis of the PHN is investigated. The expansion properties and the contact behavior are investigated.

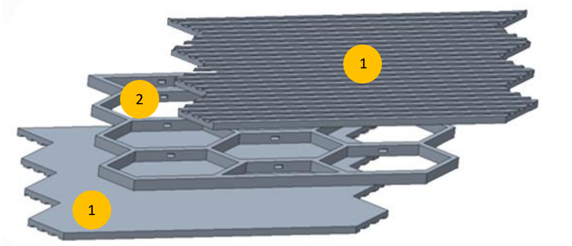

Figure 1: Components of a PHN: Outer skin with reinforcements (1) and honeycomb network (2).

COMPUTATIONAL METHODS

A parametric 2D model of the PHN was developed with material data from tensile tests using the Mooney-Rivlin 5-parameter model.

A parametric sweep is used to investigate the expanding behavior of the PHN regarding selected parameters (cf. **Figure 2**).

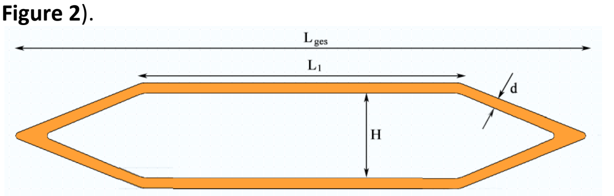

Figure 2: Selected geometric parameters of a single PHN cell.

A contact simulation of the PHN with a planar surface is performed for a selected parameter combination to investigate the contact behavior of the hyper-elastic network. The expansion of the PHN is caused through pressure on the inside of each cell (cf. **Figure 3**).

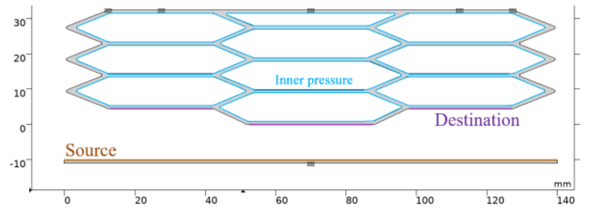

Figure 3. Contact and pressure definition for L1=30mm, d=1mm.

RESULTS

The realized model provides the possibility to investigate the contact behavior of the PHN with objects by means of contact simulation (cf. **Figure 4**).

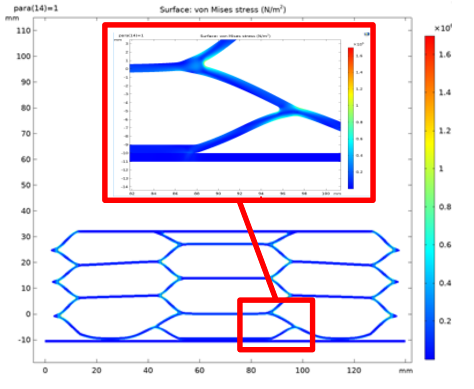

Figure 4: Stress due to expansion of the honeycomb structure.

The realized model provides the possibility to investigate the contact behavior of the PHN with objects by means of contact simulation (cf. Figure 5.). The variation of different parameter configurations provides information about the expansion behavior of the PHN (cf. Figure 6) and thus enables the construction of a highly expandable network using minimal force.

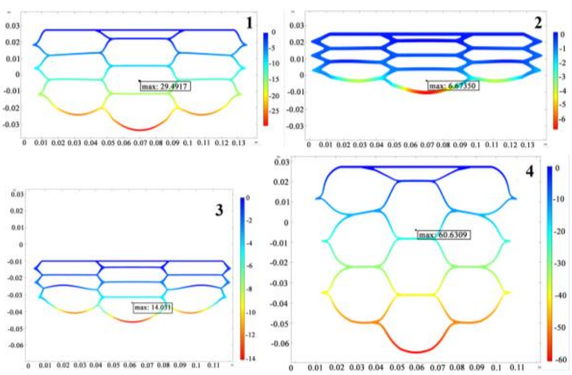

Figure 5: Variation of the thickness (1mm, **1** – 2mm, **2**) and variation of the cell connector length Li (40mm, **3** – 10mm, **4**).

CONCLUSIONS

The parametric sweep of different geometric parameters yields useful information for an optimal expansion behavior with minimal pressure and the resulting stresses inside the structure. The flexible behavior verified by the contact simulations enables various applications, for example as dynamic sealant.

The future work will involve different hyperelastic materials despite silicone for further studies, as well as an investigation of the material behavior for higher elongations.

REFERENCES

1. Triverdi, D., Rahn, C. D., Kier W. M., Walker, I. D., Soft robotics: Biological inspiration, state of the art, and future research. Applied Bionics and Biomechanics, 5(3), 99-117 (2008)