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HealthTech Innovation CONFERENCE

HealthTech Innovation Conference

Zabrze, 10 – 11th October 2022

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OPTIMIZATION OF PROSTHETIC FOOT MADE WITH THE USE OF AUXETIC METAMATERIALS

Keywords: Auxetics, Topology Optimization, Prosthetic Foot

The development in the field of designing architectured materials enables to obtain structures whose properties are often unintuitive. Among these materials, auxetic metamaterials, characterized by a negative Poisson's ratio, are distinguished. When auxetics are stretched in one direction, their structures undergo expansion in the transverse direction. During compression, the auxetic materials contract. One of the characteristics of auxetic materials is the high energy absorption [1-5].

The use of properly fitted prosthetic appliances has a significant impact not only on patient comfort. Moreover, it also affects the safety of the patient. The components of the foot prosthesis have a significant impact on the transfer of vertical ground reaction force to the lower limb joints during various activities. In this study, due to the excellent energy absorption of structure with negative Poisson’s ratio, the application of auxetics metamaterials in foot prosthesis was proposed.

The lower limb prosthesis is exposed mainly to compressive loads. In this study, the topology optimization of the auxetic structure was conducted to optimize and lightweight the analyzed unit cells (Fig. 1). The influence of geometric parameters of the auxetics unit cell was analyzed in terms of energy absorption amount. The specific energy absorption as the ratio of the total energy absorbed and the total mass of structure was evaluated.

Concluding, the conducted study enables us to indicate the auxetic unit cells whose application in the foot prosthesis is the most beneficial in terms of energy absorption. The conducted topology optimization process allowed to significantly reduce the mass of the prosthesis. The improved design of auxetic metamaterials can provide increase the safety and comfort of prosthesis usage.

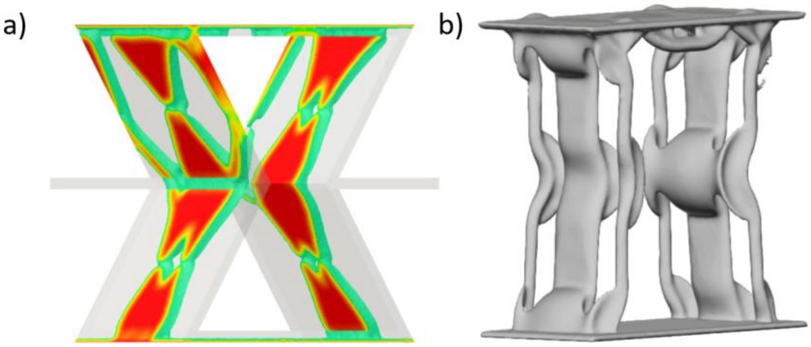

Fig. 1. The optimized re-entrant structure for compression: a) topology optimization, b) generative design.

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ACKNOWLEDGMENTS

This work has been supported by a grant from the Ministry of Education and Science in Poland: 0612/SBAD/3589 (2022) and 0612/SBAD/3588 (2022). The simulations have been made at the Institute of Applied Mechanics, Poznan University of Technology.