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Investigating the Energy Absorption Properties of TPU Auxetic Structures Produced by Additive Manufacturing

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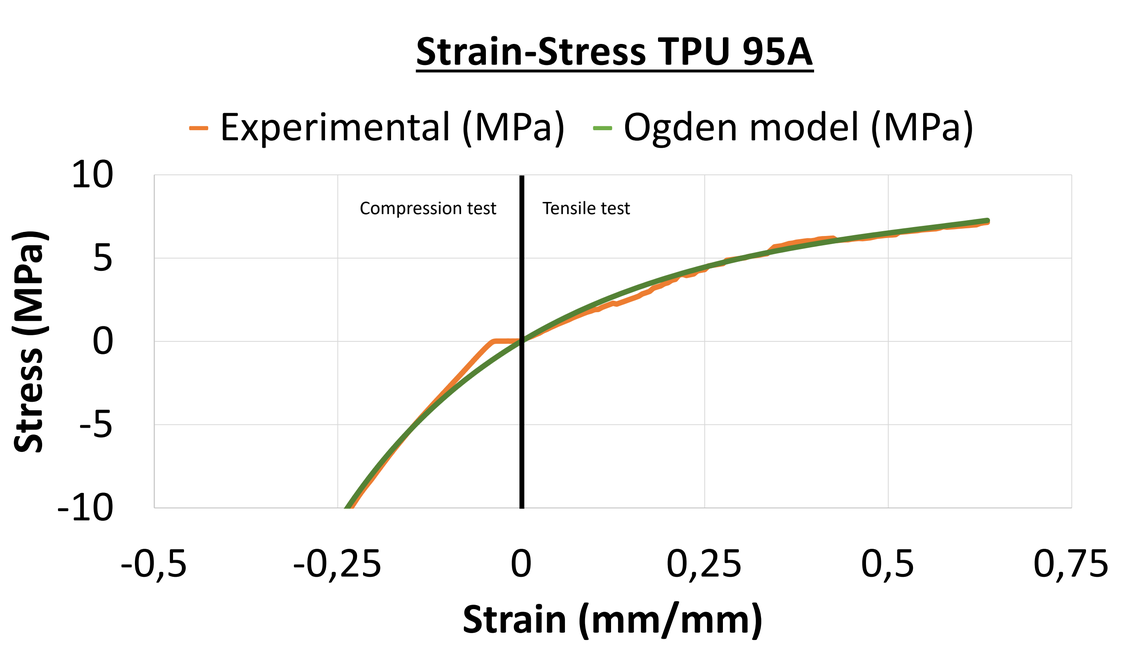
The work introduces the innovative use of 3D printing technology to create flexible auxetic structures using TPU filament, which exhibit a negative Poisson's ratio and unique mechanical properties ideal for various applications [1], [2]. The study aims to investigate the mechanical behavior of these TPU auxetic structures under tensile and compressive loads. The combination of TPU's flexibility and auxetic behavior opens up utilities, including wearable sensors, energy-absorbing structures, military protection, and sports footwear [3]–[5]. Emphasizing the advantages of additive manufacturing, the work highlights efficient and cost-effective production, overcoming conventional manufacturing limitations, and contributing to the advancement of next-generation materials with enhanced properties and diverse industrial applications. The entire study has been conducted following the relevant standards and regulations [6]–[8].

OBJECTIVE

The objective is to quantify the impact resistance and energy dissipation of TPU auxetic structures by systematically varying structural parameters, thereby informing the design of advanced protective materials.

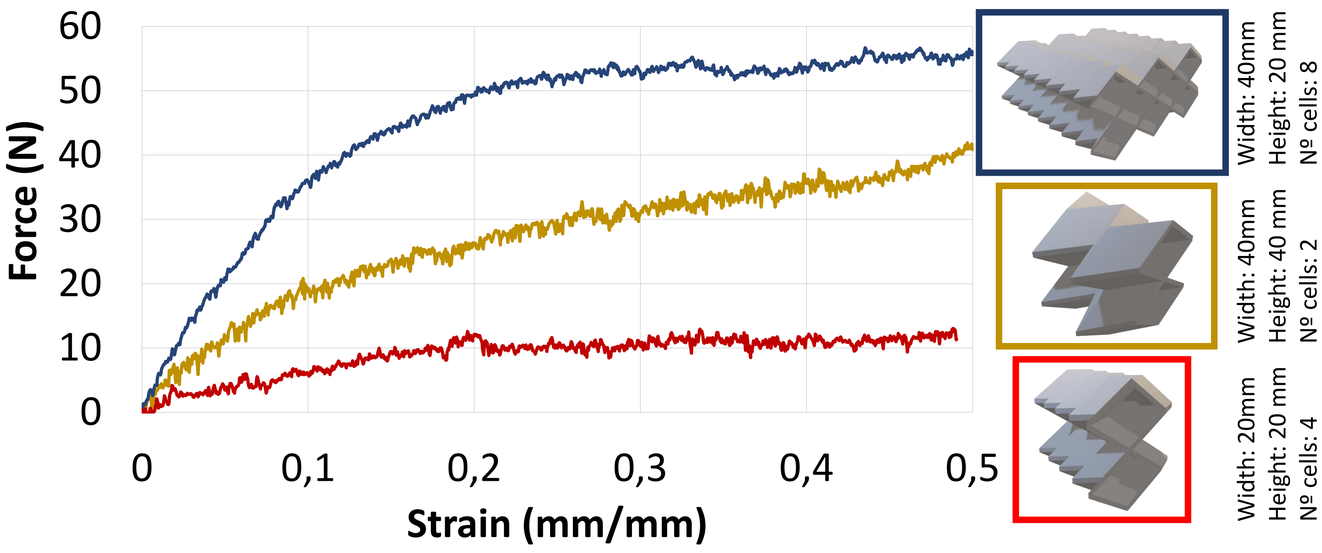
METHODOLOGY

The behavior of the TPU material was analyzed through compression and tensile tests. For this purpose, test specimens were printed using Fused Filament Fabrication (FFF) technique. Different tensile specimens were printed (infill: 100%, printing speed: 10 mm/s and printing temperature: 225°), varying the building orientation (0°, 45° and 90°) to evaluate the material's strength in all directions and thereby define its behavior. Following the literature, the obtained results were adjusted based on the Ogden criterion for hyperelastic materials. Additionally, various origami-type structures made from the same material were subjected to compression tests, analyzing their behavior and the influence of the size of each cell.



RESULTS

- Energy absorption decreases as the width and height of the structure decrease. This suggests that the compression test is more energy-efficient when the test specimen has a smaller cross-sectional area [5].
- Wider samples show significantly higher energy absorption values, indicating that larger dimensions enhance the auxetic effect and thus improve energy absorption capabilities [9, 10].



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