Mechanical Engineering Thesis Defense

Energy Absorption of Multi-Material Cellular Structures

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Abstract

Many lightweight and low-density structures are found in nature, for example, cork, wood, and sponge. Inspired by the design of these biological structures, man has made his own cellular solids. A cellular structure is a cellular solid composed of solid and gaseous phases. They consist of an interconnected network of solid struts or plates that form the cell's edges and faces. This makes them an ideal candidate for numerous energy absorption applications in the military, transportation, and automotive industries.

The objective of the thesis is to study the energy-absorption of multi-material cellular structures. Cellular structures made from Acrylonitrile-Butadiene-Styrene (ABS) – a thermoplastic polymer and Thermoplastic Polyurethane (TPU) – a thermoplastic elastomer were manufactured using dual extrusion 3D printing on Ultimaker S5. The surface-based structures were designed with partitions to allocate different materials using Matlab and nTopology. Aperiodicity was introduced to the design through perturbation. The specimens were designed for two wall thicknesses - 0.5mm and 1mm, respectively. In total, 18 specimens were 3D printed. All the specimens were tested under a quasi-static compression process on Instron 5985. A detailed analysis was performed to study the energy absorption metrics and draw conclusions. Main emphasis was given on specific energy absorbed as a function of relative density, efficiency, peak stress of the specimens to hypothesize and validate mechanisms for observed behavior. Two different approaches were considered: the role of aperiodicity in cellular structures and how multi-material cellular structures absorb more energy.

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Zoom Link: https://asu.zoom.us/j/82323595447