Investigating Foaming Materials in 3D printing

An Application for Motorcycle Helmets

This research explores foaming materials for an extrusion based 3D printer. Foaming materials for 3D printing provide the advantage of creating lightweight products which have good impact strenth in relation to their weight (Nofar, 2022). This is interesting for impact absorbing applications. Since foaming materials for extrusion based printing is relatively new, this research focusses on the following three goals:

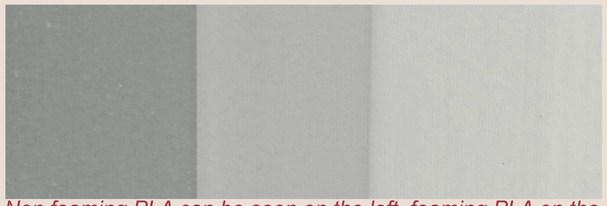
Collect available information on foaming materials for 3D printing.

Investigate the effect of printing parameters on the amount of foaming.

Investigate compressive material properties in the context of a motorcycle helmet.

Literature review

An extensive literature review is conducted, from which the conclusion is drawn that most material properties in tension are known for the foaming PLA. However, in the literature, limited knowledge is available for the foaming TPU and ASA. It is decided to further investigate the compressive properties of foaming PLA in the context of a motorcycle helmet.



Non foaming PLA can be seen on the left, foaming PLA on the right.

Nofar, M., Utz, J., Geis, N., Altstädt, V., & Ruckdäschel, H. (2022). Foam 3D Printing of Thermoplastics: A Symbiosis of Additive Manufacturing and Foaming Technology. *Advanced Science*, 9(11). https://doi.org/10.1002/ADVS.202105701

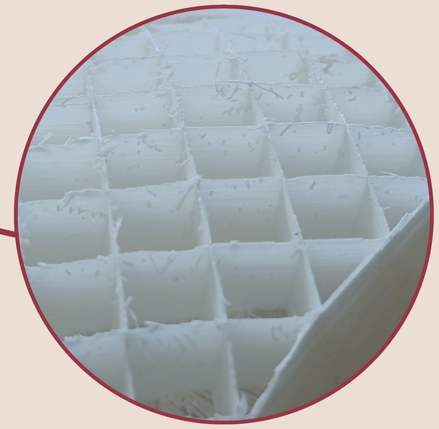
Printing parameters

The printing parameters are investigated for three materials, foaming PLA, ASA and TPU. The investigated parameters are, the printing temperature, influence of the fan cooling, printing speed and flow rate. For ASA only the first two parameters are investigated. For the foaming TPU and PLA all the parameters influence the expansion of the material. The expansion of foaming PLA and ASA are not affected by the fan cooling. It is concluded that depending on the desired outcome, printing parameters can be chosen. For example, if a dimensionally accurate lightweight PLA product is desired, the speed needs to be low (25 mm/s) and the temperature high (between 220 °C – 250°C) to obtain the most amount of foaming. By reducing the flow rate low (41% - 49 %), the dimensional accuracy is achieved.

Compressive properties

The conducted compression test shows that the foaming PLA samples printed at 25 mm/s, temperature of 250°C, flow rate of 49% and infill densities of 12% and 6% have similar compressive properties as the expanded polystyrene (EPS), that is used within motorcycle helmets. Therefore, the foaming PLA with the above mentioned properties and an infill of 6% is used to create the impact liner within a motorcycle helmet. The comfort liner is substituted by foaming TPU. This shows that 3D printing a motorcycle helmet could be an interesting topic for further research.

Motorcycle helmet with 3D printed foaming materials as impact and comfort liner



Foaming PLA printed at 250°C with 6% grid infill.

Foaming TPU printed at 240°C with 12% gyroid infill.

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