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Hybrid Manufacturing combining 3D Printing and Injection Moulding in the pursuit of Mass Customization

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Project Overview:

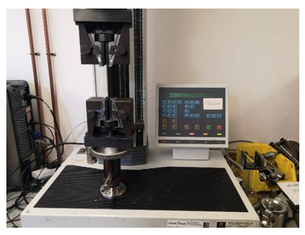
- Mass customization is a marketing and manufacturing technique which combines the flexibility and personalization of custom-made products with the low unit costs associated with mass production. The technique allows the consumer to purchase items more in keeping with their individual need and sense of taste.
- 3D printing is a versatile technique to create parts designed in complex shapes with particular structure and various properties.
- Injection moulding is a well-established process that produces mass-volume products with very high precision.
- Our approach is to combine both 3D printing and injection moulding processes for the mass customization of parts. Our first steps is to investigate the influence of processing parameters on mechanical performance.

Material and Methodology:

- 3D printed samples were fabricated with the MakerGear M2 using Simplify 3D Version-4.1.1.The stl. files used were created using SOLIDWORKS 2016 x64 Edition (Nozzle temperature 210°C, Platform temperature 110°C for ABS and Nozzle temperature 210°C, Platform temperature 60°C for PLA).
- Injection moulding was completed on the Babyplast 6/P (Mould temperature 120°C).
- Tensile testing was on the LRX single column, bench mounted materials testing system.
- Imaging was completed using Nikon ShuttlePix and Scanning Electron Microscope.
- Fully injection moulded and 3D printed samples were compared directly to test specimens produced via mass customized fabrication.
- 3d printing parameter of infill percentage was investigated - 25%,50% and 75%.
- Mass customized parts were produced in two different directions – thickness and length.
- Different interfacial architecture was added to the 3D printed samples to increase physical interlayer adhesion.
- Each batch produced 12 replicates to ensure statistical significance.
- Tensile testing was performed on each batch. Imaging captured micro and macrostructural differences.

3D printer printing the 3D part

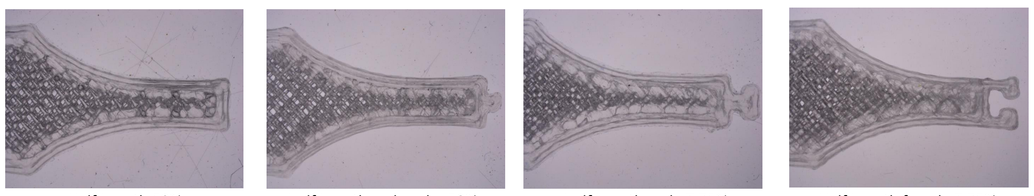

Babyplast 6/10 used in the project


LLOYD Tensile Test System used


Scanning Electron Microscope

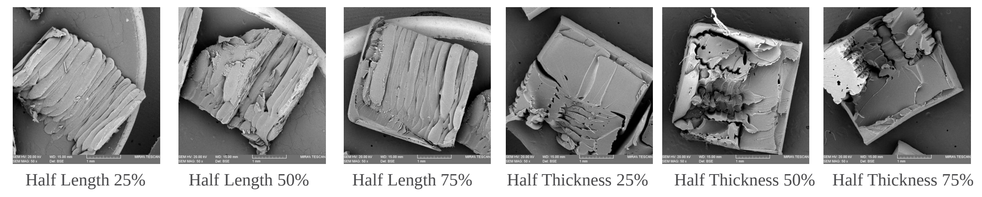
Edge-Interfaces of Printed Substrates


Half Length 25% | Half Length male cube 25% | Half Length female cube 25% | Half Length male T 25% | Half Length female T 25%


Half Length 50% | Half Length male cube 50% | Half Length male T 75% | Half Length female T 75%

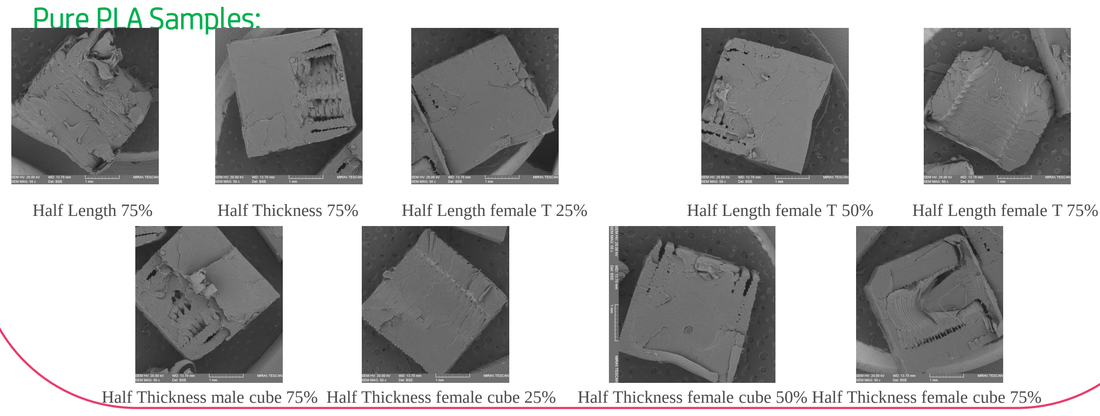
Scanning Electron Microscope for Pure ABS and PLA samples (*50):

Pure ABS Samples:


Half Length 25% | Half Length 50% | Half Length 75% | Half Thickness 25% | Half Thickness 50% | Half Thickness 75%


Half Length female T 75% | Half Length female T inset 75% | Half Thickness female cube 75% | Half Thickness female T 75%

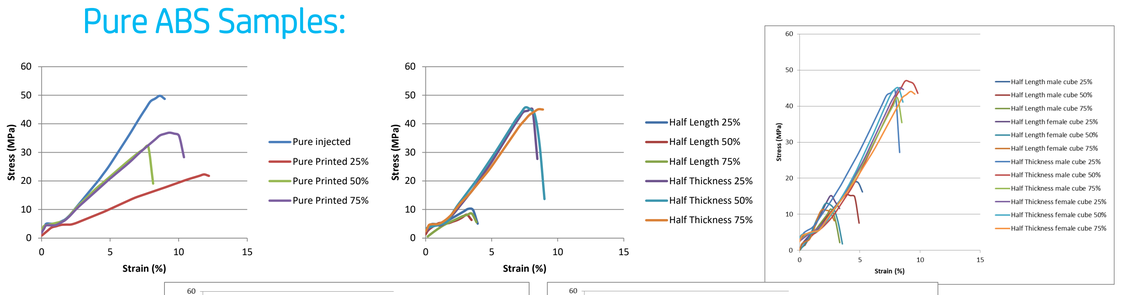
Pure PLA Samples:

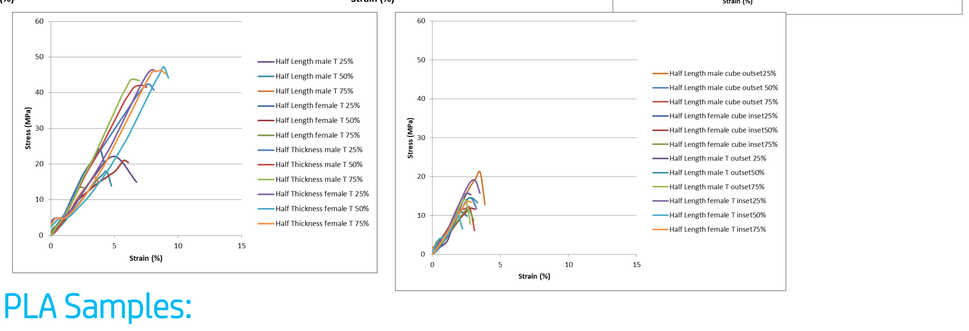

Half Length 75% | Half Thickness 75% | Half Length female T 25% | Half Length female T 50% | Half Length female T 75%

Half Thickness male cube 75% | Half Thickness female cube 25% | Half Thickness female cube 50% | Half Thickness female cube 75%

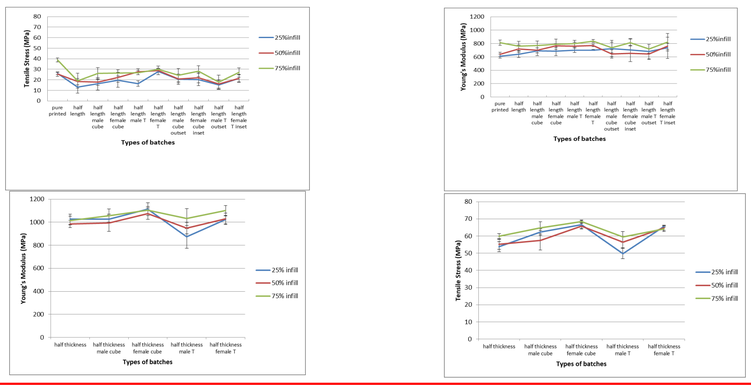
Result:

Pure ABS Samples:





Pure PLA Samples:



Discussion and Conclusion:

- 100% injection moulded samples had the best mechanical performance.
- For ABS only samples, the lower the print density the better the performance.
- For PLA only samples, the higher the print density the better the performance.
- Female printed shape better than male shape, both in ABS and PLA Samples.
- Half Thickness series samples better than Half Length series samples.
- Normal male and female shape better than outset/inset ones.

Future Study:

- The study will focus on interfacial architecture, such as cube and T inset/outset, no matter male or female.
- The study focus on mixed resin combinations, and other 3d printing technique, such as DLP i.e. non-thermoplastic materials.

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