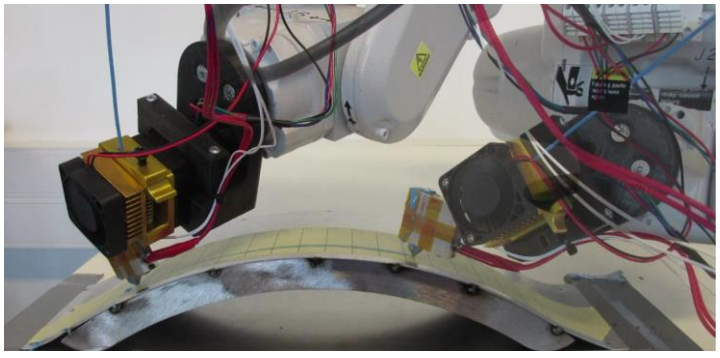
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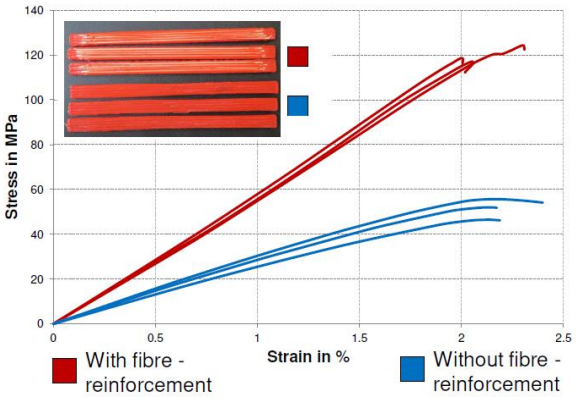


Freeform-FDM process development using natural fibre reinforced biopolymers

M. Aburaia[1] , M. Lackner[1], H. Grünbichler[1], C. Engelhardt-Nowitzki[1], E. Markl[1], H. Lammer, H. Zhang, J. Wang, J. Sapotka, T. Janics, M. Haiberger
[1]University of Applied Sciences FH Technikum Wien, Hoechstaedtplatz 6, 1200 Vienna, Austria
[2]Kompetenzzentrum Holz GmbH, [3]Shanghai University,[4]Montanuniversität Leoben, [5]Hage Sondermaschinenbau GmbH & Co KG, [6]Haratech GmbH

Whereas regular FDM (fused deposition modelling, FFF = fused filament fabrication) relies on layer-by-layer additive manufacturing, the authors demonstrate a freeform printing process using a robot and fibre reinforced biopolymers (PLA, PHB). As fibres, both conventional (glass fibre, aramid fiber, carbon fibre) and natural fibres (flax, hemp) are used. Also, nano-scaled cellulosic nano crystals (CNC) and/or carbonized biobased nanofillers are used as reinforcement. A new 5 axis/6 axis 3D printing method for load path oriented fibre placement on freeform surfaces (FFF-based and robot arm-based) was developed. A fourfold increase in tensile strength, compared to the non-reinforced polymer, was found for aramid in PLA. Current challenges are melt strand cooling and melt strand chopping. Further increase in mechanical strengthening is expected from optimization of the sizing agent. Freeform printing was demonstrated for up to 45°C of extruded strand angle, without the need for a support structure, using air cooling and regular extrusion speed. Tensile testing according to ISO 527 reveals that the print direction has a market influence of mechanical properties in tensile testing.





Mohamed Aburaia is a PhD student at the University of Innsbruck. His PhD topic deals with the usage of industrial robot manipulators for freeform prinitng. He is the deputy program director of the Master program Mechatronics/Robotics at the University of Applied Sciences Technikum Wien. He is also the project manager of a research facility that uses industrial robots to simulate processes and value chains that are analyzed and optimized concerning Industry 4.0 and related challenges.

Full name: Mohamed Aburaia
Contact number: +43 1 333 40 77 502
Email id: aburaia@technikum-wien.at
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