Future perspectives of (continuous fibre reinforced) composite additive manufacturing

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Extrusion based additive manufacturing (AM) techniques for thermoplastic materials have been developed during the last thirty years. In order to improve limitations in mechanical, physical and thermal properties such as strength, stiffness, toughness and heat deflection behaviour of additively manufactured products compared to their injection moulded counterparts, short fibre filled AM materials have been introduced more recently. To expand the possibilities of the extrusion-based AM materials even further, processing methods for both (bio-based) composite blends and incorporation of continuous fibres into polymer matrix has been developed such as e.g. (bio)composites and Continuous Fibre Additive Manufacturing (CFAM) [1].
CFAM combines a thermoplastic polymer matrix and a continuous fibre bundle into a well-impregnated [2] composite material right before its deposition, forming a 3D object. This process enables the manufacturing of complexly shaped parts that cannot be produced using traditional subtractive production technologies and gives the possibility to tailor fibre orientation [3], which is not always possible using the classic composite lay-up processes. These two advantages could lead to lighter, stronger and stiffer parts for use in high-end applications. An important disadvantage of CFAM parts is their reduced strength in z-direction due to a limited bonding between the successively printed layers. Therefore, the research also investigates the quality of the interlayer cohesion as a function of parameters such as processing temperatures, layer thickness, road width and printing velocity of composite samples with unidirectional fibre orientation. A qualitative assessment of the interlayer cohesion and void morphology was performed on micrographs, showing the samples' cross sections perpendicular to the fibre orientation. Flexural moduli and strengths of samples printed with different processing parameters were compared quantitatively in order to find optimal processing parameters. This research will lead to a better understanding of the interlayer cohesion in CFAM composites and will determine the possible added value of the technique compared to currently existing fibre reinforced AM processes.
Parallel research on composite blends also investigated how brittleness, slow crystallization rate and poor heat resistance of PLA blends may limit its usage in AM applications. To improve the performance of AM processed thermoplastic parts, reinforcement with short carbon fibres [5,6] is one of the possible methods. Another possibility to increase diffusion, layer bonding and crystallinity is annealing [5,6,7]. Within this research, the elastomer poly(butylene adipate-co-terephthalate) (PBAT) was blended with PLA. Modulus and impact strength of PLA/PBAT blend improved with incorporation of cloisite-15 and increased significantly after annealing.

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