Optimisation of interlayer cohesion in additively manufactured continuous fibre composites

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Extrusion based additive manufacturing (AM) techniques for thermoplastic materials have been developed during the last thirty years. In order to avoid limitations in mechanical properties such as strength, stiffness and toughness 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, a process which incorporates continuous fibres into polymers was developed: Continuous Fibre Additive Manufacturing (CFAM) [1]. This process 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 additively manufactured parts is their reduced strength in the z-direction due to a limited bonding between the successively printed layers. Therefore, this research investigates the quality of the interlayer cohesion as a function of parameters such as processing temperatures, layer thickness, road width, printing velocity, etc. of composite samples with unidirectional fibre orientation, produced using the CFAM technique. 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 additively manufactured continuous fibre composites and will determine the possible added value of the CFAM technique compared to currently existing processes.

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[2] W. Van De Steene, J. Verstockt, J. Degrieck, K. Ragaert , L. Cardon, An Evaluation of Three Different Techniques for Melt Impregnation of Glass Fiber Bundles With Polyamide 12, Pol. Eng. Sci., 2017.

[3] W. Van De Steene, K. Ragaert, L. Cardon, A novel process for tailored stiffness and strength in extrusion based additive manufacturing, Pol. Proc. Soc. 2017.