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# Prediction of Mechanical Properties of Additively Manufactured Short Fiber Reinforced Composites by Homogenization

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The additive manufacturing (AM) of high-performance short fiber reinforced polymer (SFRP) composites produces a unique set of morphological features, which makes their mechanical properties differ substantially from their more well-know injection molded counterparts. Until recently, the study of theses kinds of solids was performed with artificially generated representations of their microstructure, which lacks in exhibiting the richness of features of real materials, and notably was confined to low filling fractions (<10 vol.%) [1]. To overcome these limitations, in recent years image analysis tools have been developed to allow the extraction of individual reinforcements from tomographic data. It now becomes possible to use this information as a basis for homogenization models, to predict the stiffness of the produced solids.

While finite element analysis is the most common approach for this kind of homogenization, when using high filling ratio of reinforcements (>20vol.%) the high complexity of the microstructure and the frequency of contact between fibers makes meshing an enormously complicated task[2]. Instead, the homogenization was performed using the Fourier transform-based homogenization method developed by Moulinec and Suquet, and implemented in the Amitex software, which does not require any meshing, but a regularly-spaced volumetric description of the microstructure. First the stiffness characteristics of the polymer matrix and the reinforcements by themselves were measured experimentally. Then, samples of the composite material were scanned in a micro computed tomography apparatus, and a specialized software was used to extract the constituent phases present. This description was then used as a starting point for the homogenization procedure in the Amitex software package.

Using this method, a full accounting of the microstructural features is permitted when calculating the elastic properties of these kinds of solids, which to the authors knowledge has never before been possible, mainly due to the complexity of the microstructure. Having this methodology to predict the mechanical properties from tomographic scans will make the detailled simulation of real parts obtained through additive manufacturing much simpler and more reliable.

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