Effective heat conductivities of partly infiltrated fibrous media

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The present work has been motivated by the context of feeding a global model of thermal-gradient chemical vapour infiltration process for the fabrication of fibre-reinforced ceramic matrix composites: the heat conductivity has to be known in the material as a function of the pore volume distribution, at different stages of infiltration. Since the composite preform is made of woven fibres, the medium is highly anisotropic: the heat conductivity has a tensorial character which has to be retrieved.

We propose an approach based on a double up-scaling. First, the fibre-scale effective longitudinal and transverse conductivities are computed for several volume fractions of matrix and fibres, using a periodic unit cell as a computational domain. The second change of scale takes precisely into account the actual architecture of the composite thanks to 3D X-ray tomographic imaging. The 3D blocks are processed in order to retrieve the local orientation of the fibres in various sub-domains; the local heat conductivities are then affected to the sub-domains, and a volume averaging procedure is applied for the determination of the global effective conductivity.

Several application examples are presented and discussed.