

Application of the Proper Generalized Decomposition to the simulation of RTM process

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Abstract

Simulation of RTM processes in thin plate geometries is usually performed in 2D. Thus, only a mesh of the middle plane is needed with the associated degrees of freedom yielding significant savings with respect to a fully 3D modeling. However such modeling needs the definition of an equivalent in-plane permeability representing the ignored dimension (the plate thickness). The definition of such permeability is not a trivial task because each ply in the thickness direction can be anisotropic, the principal anisotropy direction being different from one ply to the neighboring plies. In this work we propose a novel fully 3D modeling whose computational cost of the same order as a 2D solution. It allows addressing properly the equivalent in-plane permeability issue as well as other issues induced when averaging over the thickness dimension.

The most common RTM flow model spawns from Darcy's law, which in combination with the flow incompressibility yields the following elliptic differential equation in the flow domain:

$$\nabla \cdot (\mathbf{K} \cdot \nabla p) = 0.$$

The velocity field \mathbf{v} is computed from the pressure field p through the permeability tensor \mathbf{K} : $\mathbf{v} = -\mathbf{K} \cdot \nabla p$. In the case of laminates one can usually define a permeability tensor in each ply. In 3D, we can therefore assume the following variable separated representation:

$$\mathbf{K}(x, y, z) = \mathbf{M}(z) \cdot \mathbf{K}(x, y),$$

where $\mathbf{M}(z)$ accounts for the different orientations of the plies in the z dimension.

In this application of the PGD method, we seek similar separated representation of the pressure field:

$$p(\mathbf{x}, z) \approx \sum_{i=1}^{i=N} X_i(\mathbf{x}) \cdot Z_i(z).$$

We show that, almost independently of the number of plies, such 3D solution can be obtained, at the computational cost of a 2D solution. Finally we investigate some issues that such modeling can address, such as the definition of equivalent averaged in-plane permeability, or mixing issues.

References

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