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DETERMINATION OF LOCAL FIBER UNDULATION CAUSED BY VOID INCLUSIONS IN CARBON FIBER REINFORCED POLYMERS USING COMPUTATIONAL FLUID DYNAMICS

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Summary. *In this paper, image-based morphology of voids in carbon fiber reinforced polymers is obtained by interpolation of cross section images. Subsequently, computational fluid dynamics is used to determine local fiber undulation caused by production induced void inclusions. The resulting information on local fiber undulation is used to set up mesolevel finite element models. Finally, non-linear finite element simulations using a progressive failure model are carried out to predict compressive strength.*

1. INTRODUCTION

Predicting the material properties of composite structures with porosity defects is still an unsolved issue. In previous works, the authors have numerically investigated single unidirectional plies and have shown that the fibre misalignment angle due to the void inclusions leads to kink band formation under compressive loads and can thus not be neglected [1]. However, when using image analysis based void morphology to set up finite element models as presented in [2], fiber undulation can not directly be obtained. In this paper, local fiber undulation around void inclusions is determined by solving a steady state laminar flow problem.

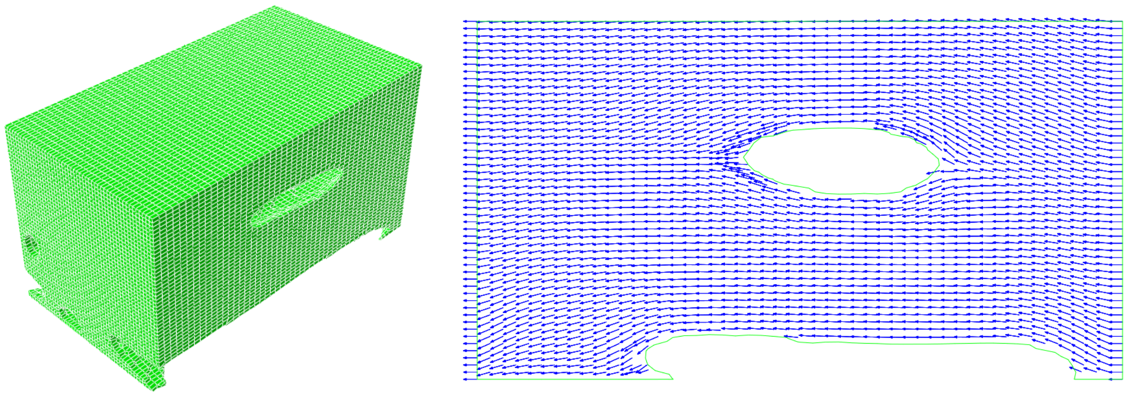
2. MESH GENERATION

High resolution cross section images of the laminate are taken. From these images, the void morphology is extracted, using phase indicator functions by using an image filter. Three-dimensional morphology of the voids is obtained by using several cuts in depth direction and the resulting phase function is meshed. Mesh smoothing algorithms are applied to improve mesh quality. A Taubin smooth is selected, as this results in a smooth mesh while preserving the original surface. *SnappyHexMesh* is used to automatically create a conforming mesh. A resulting mesh is shown in Figure 1(a).

3. DETERMINATION OF FIBER ORIENTATION

Motivated by the simulation of resin flow in infusion-type manufacturing methods as presented in [3], local fiber undulation around void inclusions is predicted by solving the incompressible Navier-Stokes equations in the domain defined by the voids:

$$\frac{\partial v}{\partial t} + (v \cdot \bigtriangledown)v = - \bigtriangledown \bar{p} + \nu \Delta v + \bar{f} \tag{1}$$



(a) Resulting volume mesh created by *SnappyHexMesh*

(b) Local fiber orientation as result of CFD calculation

Figure 1. Determination of local fiber undulation

The resulting local fiber orientation for one void block is depicted in Figure 1(b). Considering the resulting fiber orientation, non-linear finite element simulations using a continuum damage approach with progressive failure are carried out to predict compressive strength.

References

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