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A MESHING TECHNIQUE DEDICATED TO COMPLEX WOVEN COMPOSITE STRUCTURES

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We propose a robust methodology to obtain finite element models of Representative Volume Element of complex woven structures in order to characterize their mechanical properties. Complex weaves can be automatically processed with this technique. Much emphasis in the work is put on meshing difficulties.
In order to predict and characterize by finite element analysis the mechanical behaviour of complex woven structures such as interlock composite, a Representative Volume Element (RVE) must be created. The difficulties to create a mesh of these structures are well known: interpenetration, multiple contacts between yarns, meshing of thin resin layers at interfaces. . To address these problems with a finite element analysis, a discretization by voxels [1] [2] may provide a flexible solution but only offers a rough approximation of geometry. Other approaches have been proposed [3] based on the management of contact by specific models such as Multifill [4] or on the use of geometric models which reduce the number of intersections [5] or even correct the interpenetrations [6]. We propose here an approach which is based on the creation of a conforming adapted mesh at the interface between yarn surfaces into contact and on the control of the gap between facing surfaces in order to avoid the creation of ill-shaped elements.
The different steps required to create the finite element model are briefly presented here.
A "realistic" geometry that minimizes intersections between yarns is first created. An analytical model defining paths of yarns along the wefts yarns and in which contact areas can be identified analytically is proposed. The geometry of yarns is defined by swept surfaces along a guide curve. The sweep profile is assumed to be elliptical.

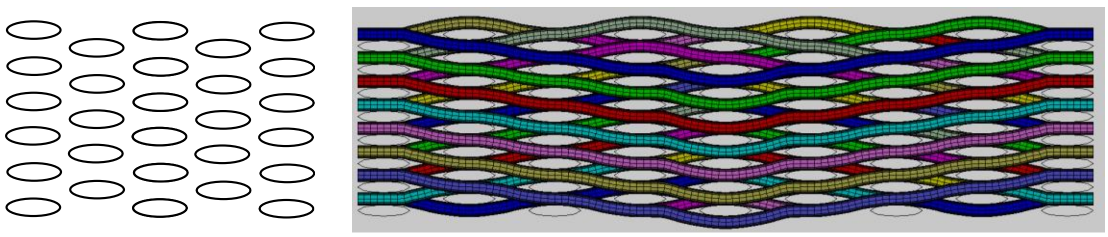

Figure 1: Network of weft yarns and the path of the warps yarns

A surface mesh is thereafter performed in the parameter space of the surface of the yarns by the use of a multi-quadtree method. The idea is to cut recursively the initial regular mesh by dividing the cells containing points into contact, close to other yarns or faces of the RVE. To obtain a conform mesh at interfaces, the warp yarns inherit by projection the intersections created on the wefts yarns. The final mesh of surfaces is obtained by re-meshing with a 2D mesh generator the points generated by the adaptive grid.

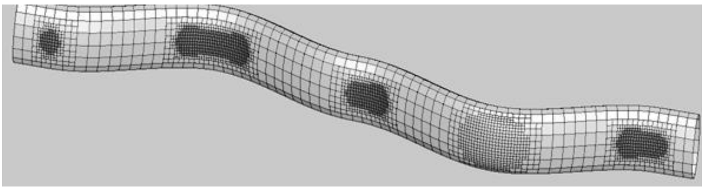

Figure 2. 3D adapted grid multi-quadtree

Once the meshing of all yarns and all the contact areas has been performed, yarns are trimmed to ensure the conditions of symmetry and periodicity of the RVE. The last step before the three-dimensional tetrahedral meshing is to create the faces of the RVE. As the mesh is made of 4 nodes or 10 nodes tetrahedral, a specific procedure must be developed to determine the orientation of the fibres.

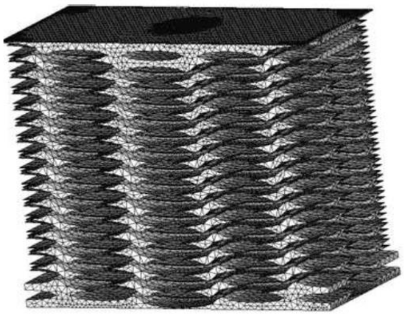

Figure 3. Meshing of the resin of a complex architecture

One the mesh is obtained, periodic homogenization techniques on the RVE are used to obtain the mechanical properties. The results (mechanical properties, computational cost) are compared to other models from the literature.

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