Feasability study for a composite carabiner
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Objectives
• Study the feasability of a composite carabiner with braided fabrics.
• Create a model to compute the mechanical properties of braided fabrics depending on the braid angle.
• Model the geometries of the braided fabrics using the open source software TexGen.
• Model a simple carabiner geometry with the properties found for the braided fabrics with the unit-cell models.

Unit-cell modelling
• Assumptions made on the geometry to find the parameters.
• Unit-cells modelled on 3D with periodic boundary conditions.
• Material:
  • Linear-elastic for the yarns
  • Elasto-plastic for the matrix.
The materials used are high resistance carbon fibers and PEEK matrix.

Modelling procedure on Abaqus CAE 2017
Sheared Out 2x2 Regular geometry
Unsheared 2x2 Regular geometry
Sheared In 2x2 Regular geometry
Principal material axis

Carabiner models
Load cases
Closed-gate model
Open-gate model
Geometries
Closed-gate model
Open-gate model
Contact definition
Mesh

Results
Tsai-Hill
Tsai-Hill to evaluate matrix yield.
The Tsai-Hill criterion shows matrix failure of all plies except for the UD ply in the open-gate model.

Stress in fiber direction
UD ply
In the 3mm UD ply the maximum tensile and compressive stress in the fiber direction are below the failure strength of the fibers.

The thickness of the UD ply can be decreased until 2mm without failure of the fibers.

Conclusion
• The carabiner model shows matrix failures but the fibers does not fail during the simulations.
• The weight of the open-gate carabiner (without the gate) with a 2mm UD ply is 27.64g. It is not as low compared to geometries on the market but this geometry is not optimised and bigger than the real geometries.
• The model can be improved by getting a larger range of braid angles. A curve can be obtained with the properties of the braided fabrics in function of the angle and these properties can be directly implemented to each element depending on its positions.