Effect of Fiber Orientation on the Thorough Thickness Permeability of Unidirectional Fabrics

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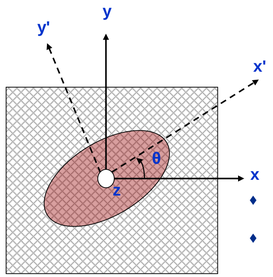
INTRODUCTION

- Numerical simulations of composites require one to provide the permeability tensor of the preform
- A reliable and accurate method to characterize permeability is needed
- Resin impregnation is modeled by Darcy's law:

$$u = -\left(\frac{K}{\mu}\right)\nabla P$$

- Permeability tensor:

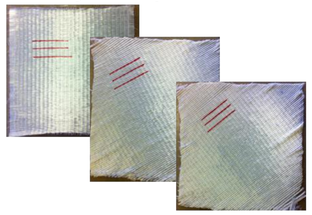
$$K=\begin{bmatrix} K_{xx} & K_{xy} & K_{xz} \\ K_{yx} & K_{yy} & K_{yz} \\ K_{zx} & K_{zy} & K_{zz} \end{bmatrix}$$



- x, y, z: mold coordinate system
- x', y' : preform in-plane principle axis

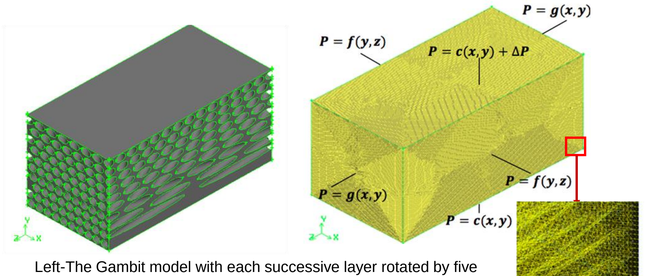
MOTIVATION

- Using uni-directional fabrics:
  - slight misalignment during the stacking can change the through-thickness permeability component
  - characterization of through-thickness permeability of a series of uni-directional fabrics stacked in various orientation pathways is crucial
  - numerical and experimental analyses are performed to predict the through-thickness permeability component



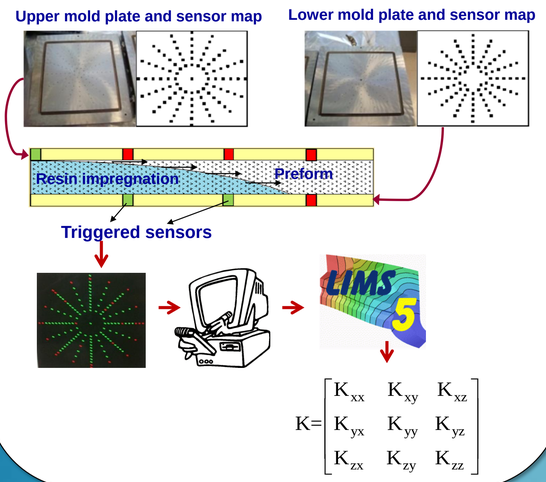
NUMERICAL IMPLEMENTATION

- Simulation of laminar viscous flow through open regions and fiber tows of a unit cell
- Through thickness characterization;
  - Gambit is used for mesh generation, periodic boundary and domain settings
  - ANSYS Fluent is used for numerical solution



Left-The Gambit model with each successive layer rotated by five degrees.
Right-Gambit mesh of the model with periodic boundary conditions. The cutout shows the mesh density.

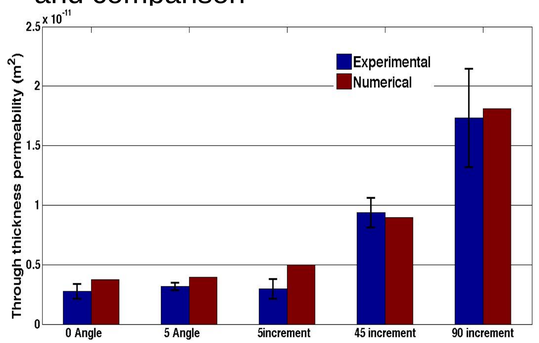
EXPERIMENTAL SET-UP



$$K=\begin{bmatrix} K_{xx} & K_{xy} & K_{xz} \\ K_{yx} & K_{yy} & K_{yz} \\ K_{zx} & K_{zy} & K_{zz} \end{bmatrix}$$

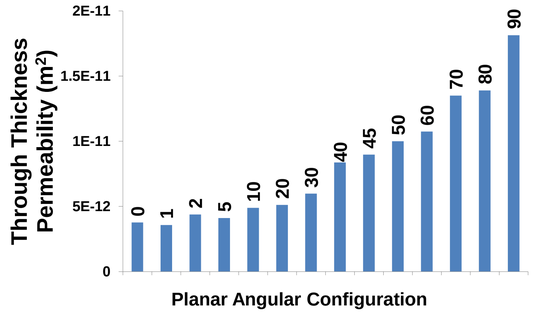
RESULTS

- Experimental and numerical through-thickness permeability characterization and comparison



RESULTS

- Change in through thickness permeability with increasing rotation angle of the successive ply



CONCLUSION AND FUTURE WORK

- The effect of changing ply orientation of successive uni-directional fiber plies in the laminate on the through thickness permeability is investigated
- Numerical model shows good agreement with experimental results
- Influence of ply orientation and volume fraction of uni-directional fabric on transverse permeability can be explored with the numerical model.

ACKNOWLEDGEMENTS

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