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Latest news from the academic research
• Institute of Civil Engineering & Mechanics (GeM) at a glance
• Overview of recent research topics addressed in composite processing
• Examples
Research scope @ GeM

2004 Creation

3 locations
- University of Nantes
- IUT Saint-Nazaire
- Centrale Nantes

230 people
- 75 Faculty members
- 40 Eng. / Tech. / Admin.
- 110 PhDs

10 experimental Lab.

3 supervisory authorities

Université de Nantes

ImaM

6 Research Groups
- Materials-Environment-Structures
- Modeling & Simulation
- Processes & Mechanics of Materials
- Mechanical states and Microstructure of Materials
- Water-Geomaterials Interactions
- SHM, Reliability and Structural Mechanics

Nantes Métropole
Research scope @ GeM

Experimental

Materials

Focus

Expertise

Models

Structures

Simulation

Manufacturing Processes
Overview of recent Composite Manufacturing Research Topics

Forming
- Dry fabrics, dry tows
- Viscous discontinuous prepgs
- Structural compounds

Flow
- Rigid & slightly deformable fibrous media
- Large deformations in fabrics

- Tailored Fiber Placement, debulking
- QSP
- SMC compression
- RTM, LRI, Pultrusion, consolidation
- RTM with on-line mixing of reactive resin
- Fiber washing in CRTM & consolidation

K. El Azzouzi, A.S. Lectez, J. Simon
G. Sorba, P. Mulye
L. Oter, F. Mahé
A. Babeau, B. Martin, T. Kourkoutsaki, E. Lopez, J. Hemmer, S. Bancora
M. Imbert, A. Moisy
H. Aimé, A. Hautefeuille, G. Gambarini
Compaction of dry fabrics: mesoscale modelling
Forming of discontinuous TP composite layups

2D ply stack before forming

Final formed component after QSP
Forming of discontinuous TP composite layups

(a) Slave Node
Penetration Zone
Master Surface

(b) Slave Node
Adhesion Zone
Penetration Zone
Master Surface

SMC Compression

Flow of fiber suspensions

- Injection (reinforced thermoplastics, BMC, ...)
- Compression molding (Sheet Molding Compounds)

Theory of fiber suspensions \([2, 3]\)

\[
\frac{d}{dt} A_2 = WA_2 - A_2 W - \Lambda (DA_2 + A_2 D - D : A_4)
\]

- Rotation due to the vorticity
- Alignment with the shear flow

Distribution of orientation

Orientation tensor \(A_2\)

Classic assumptions:

- Undisturbed flow
- Moving solid particles
Liquid Resin Infusion

Micro-CT : In-situ experiment

Wet TP pultrusion

Compaction and Impregnation increase

Product scale

Tow scale
Wet TP pultrusion

\[ \nabla \cdot \mathbf{u} = -q(P, S) \]

\[ q = \epsilon_{\text{micro}}(1 - \epsilon_{\text{macro}})U \frac{dS}{dx} \]

\[ \frac{dS}{dx} = \frac{1}{U} \frac{aP}{\beta \eta} \left( e^{(b(1-S)^c} - 1 \right) \]

\[ \langle u \rangle - \epsilon_{\text{macro}}U = -\frac{K}{\eta} \nabla P \]

\[ \rho cU \frac{\partial T(x, z)}{\partial x} = \frac{\partial}{\partial z} \left( k \frac{\partial T(x, z)}{\partial z} \right) \]

\[ \eta(T) = a \exp \left( -\frac{T}{b} \right) \]
Fiber washing

Compression system

Sample

Support bench

Optical system

Data acquisition

Twill-Weave sample

Quasi-UD sample
Fiber washing

Porous media flow

Coupled axial porous flow and transverse squeeze flow

Q&A

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Thank you!