Les composites polymères : MSE340-2025

Introduction-Conclusions

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Matériaux, procédés, propriétés

CALENDRIER	MSE 340 COMPOSITES			
	TP composites	Cours composites		
	lu 8-12h MED	lu 14-16h MXG110		
lundi, 8 septembre 2025		Cours	Intro aux composites	PEB/VM
lundi, 15 septembre 2025	Organisation	Cours	Constituants des composites	VM/PEB
lundi, 22 septembre 2025	férié	férié		
lundi, 29 septembre 2025	TP	Cours	Bases théoriques de la mise en œuvre des composites	VM
lundi, 6 octobre 2025		Cours	Procédés de mise en œuvre des composites	VM
lundi, 13 octobre 2025	TP	Cours	Procédés de mise en œuvre des composites	VM
lundi, 20 octobre 2025				
lundi, 27 octobre 2025		Cours	Intro à la mécanique des composites	PEB
lundi, 3 novembre 2025	TP	Cour		
lundi, 10 novembre 2025		Cour		
lundi, 17 novembre 2025	TP	Cour		
lundi, 24 novembre 2025		Cour		
lundi, 1 décembre 2025	TP	Cour		
lundi, 8 décembre 2025		Cour		
lundi, 15 décembre 2025	TP	Cour		
EVALUATION: 1/3 rapports des TP, 2/3 examen				

Learning outcomes

A la fin de ce cours l'étudiant doit être capable de:

- Appliquer les méthodes de calculs pour déterminer les propriétés mécaniques des matériaux anisotropes
- Dimensionner des structures en composites (simples)
- Proposer des matériaux en choisissant leur composition et les procédés de fabrication pour une application donnée
- Comparer les matériaux composites entre eux
- Discuter les tests de caractérisation des composites
- Distinguer les avantages et limitations des procédés.

- Dialoguer avec des professionnels d'autres disciplines.
- Utiliser les outils informatiques courants ainsi que ceux spécifiques à leur discipline.

5 TPs sur la mise en oeuvre et les propriétés des composites
Examen oral en Janvier

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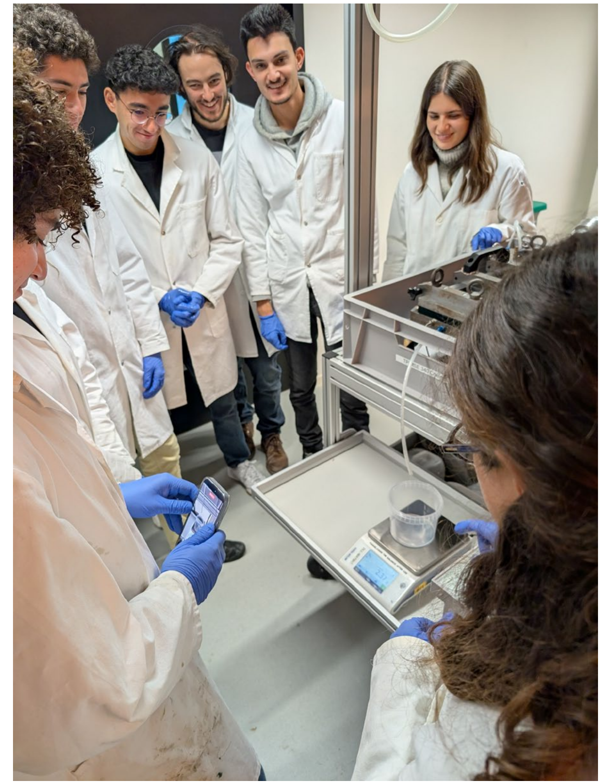
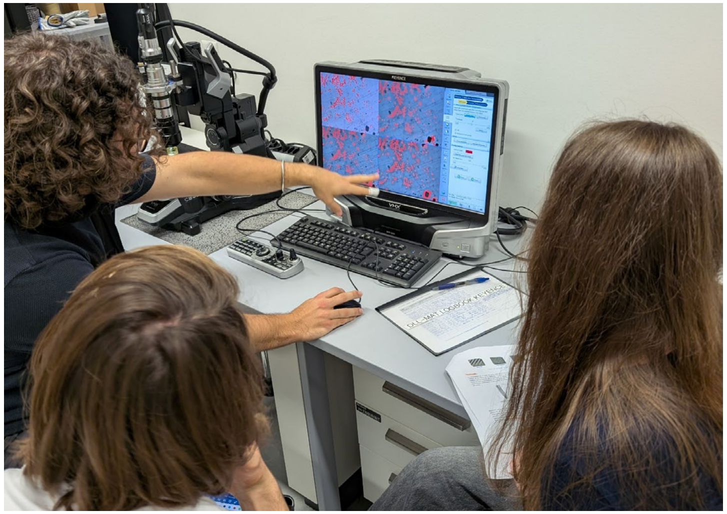
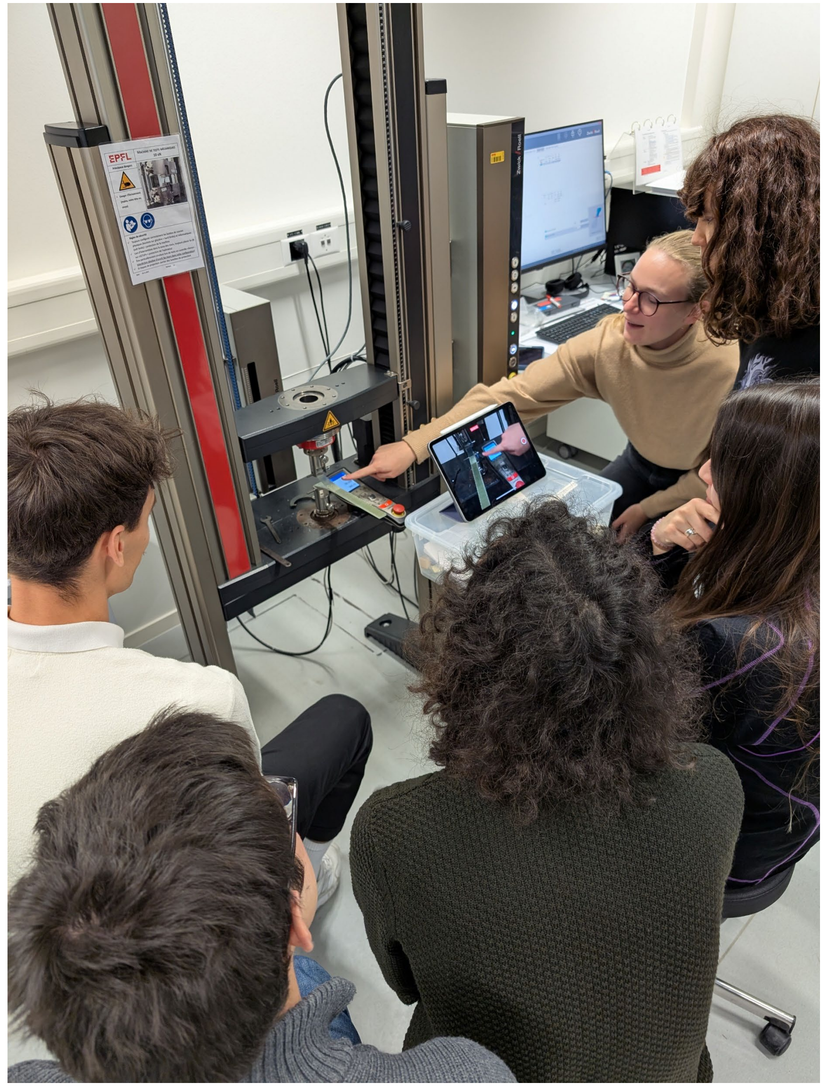
TP



TP





Constituants

Renforts

B: Flexibilité

Flexion d'une poutre cylindrique:

E module, I moment d'inertie
$I = \pi d^4/64$

R rayon de courbure
et M moment de flexion

$R = EI/M = E\pi d^4/64 M$

Donc R est proportionnel à d^4.

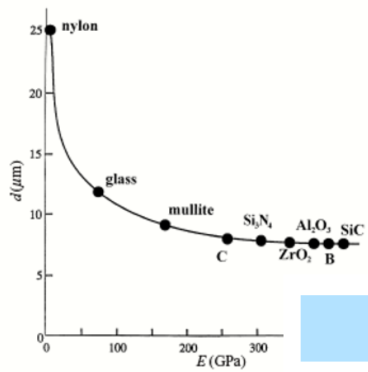


Figure 1
Diameter of various fibers with a flexibil
of a 25μm diameter nylon fiber. Given a
diameter, it is possible to produce, in pr
flexible fiber from a polymer, a metal, or

Les matrices polymères

Thermodurcis

Avantages

- \+ Résines liquides à T ambiante
- \+ Facilité de mise en oeuvre (EP, UP)
- \+ Durcissement entre 5 et 180C (EP)
- \+ Prix raisonnable
- \+ Grande variété de formulation possibles
- \+ Bonne adhésion aux fibres
- \+ Amorphe

Inconvénients

- \- Volatilité, toxicité, allergies
- \- Résistance à l'humidité
- \- Résistance aux chocs
- \- Controle de la réaction chimique

Thermoplastiques

Avantages

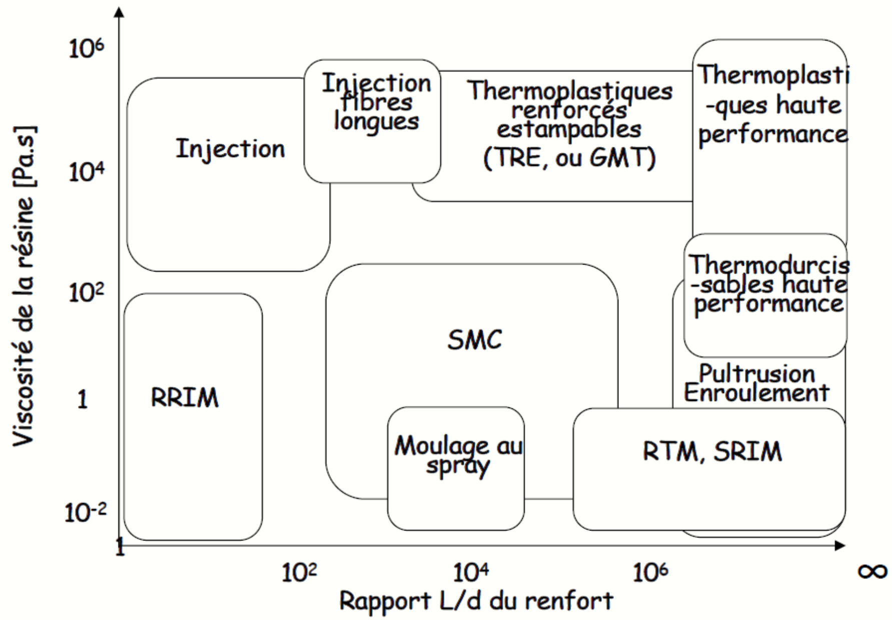
- \+ Mise en oeuvre rapide, par élévation de T
- \+ Procédés de mise en ouvre des thermoplastiques utilisable avec les fibres courtes
- \+ Bonne résistance à l'humidité
- \+ Recyclage aisé

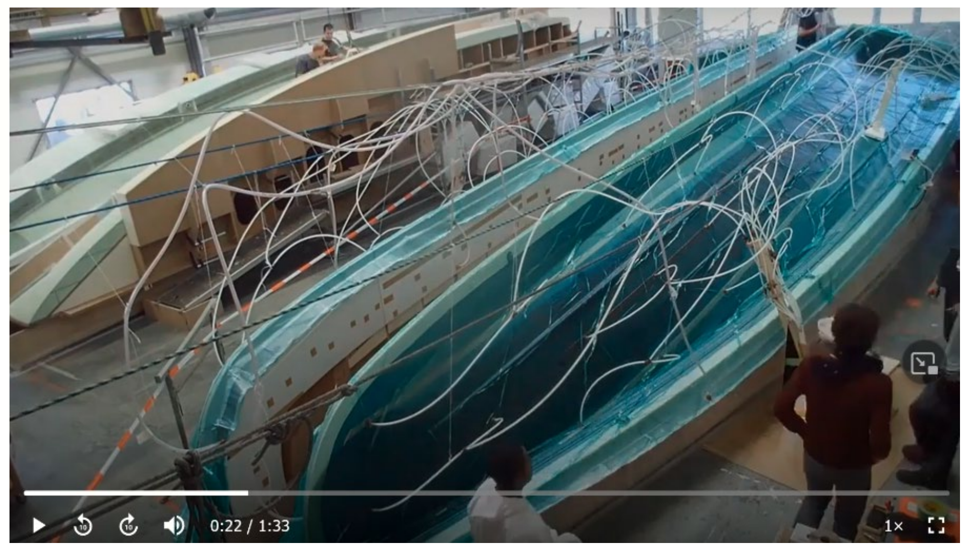
Inconvénients

- \- Souvent peu résistantes à la T
- \- Retrait au moulage (matrices s- c)
- \- Mauvaise résistance chimique
- \- Adhésion aux fibres souvent problématique
- \- Propriétés mécaniques faibles, fluage

Vitrimères : Nouvelles résines (depuis 2010 environ), basée sur une chimie de reseaux covalents adaptatifs (CAN), par exemple entre alcool et ester, qui sont réticulés mais peuvent être reformés en chauffant, et mieux recyclés.

Mise en oeuvre





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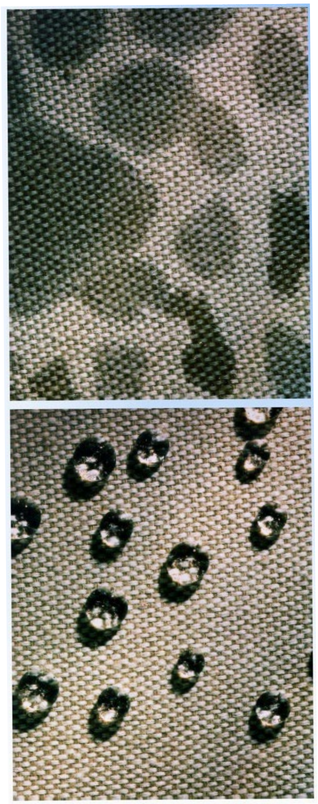
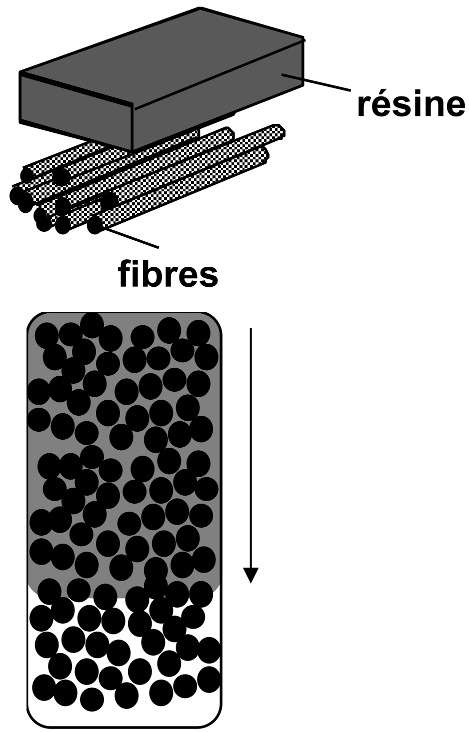
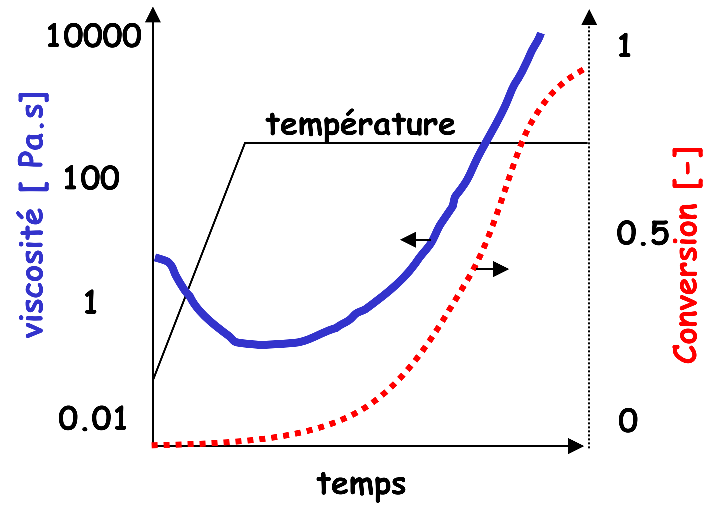
Les phénomènes







Mouillabilité
Tensions de surface
…

Imprégnation
Perméabilité
….

Transformation de la matrice

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? mise en oeuvre

Quel polymère et quelles fibres pour un pare-chocs de voiture ?

Décrivez la mise en œuvre par SMC ?

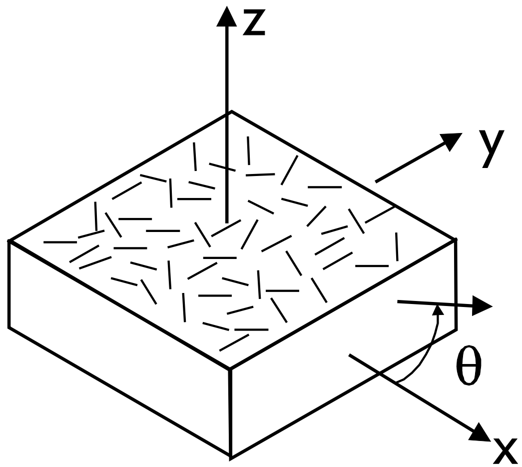
Citez 3 résines thermodurcissables ?

Comment pouvons nous déterminer la perméabilité ?

...

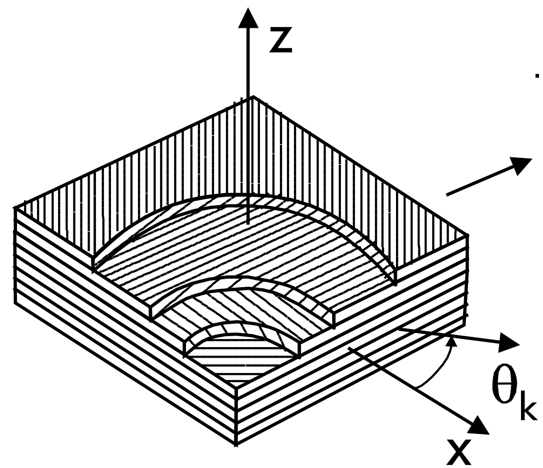
Mécanique des composites : propriétés

Composites à fibres courtes



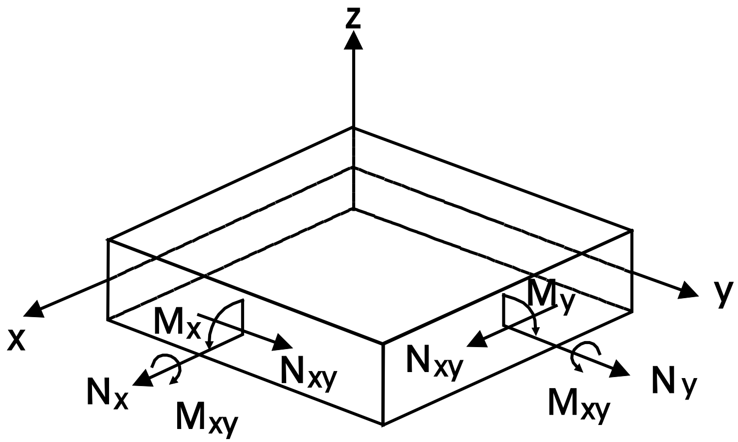
$$E_I = E_f\, V_f \left[1 - \frac{\tanh(\beta\ell/2)}{\beta\ell/2} \right] + E_m\, V_m$$

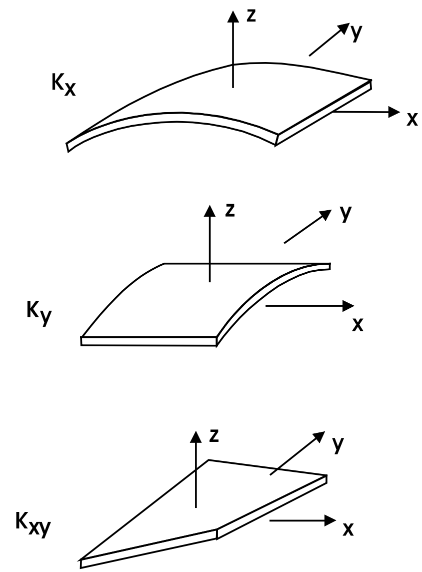
Stratifiés



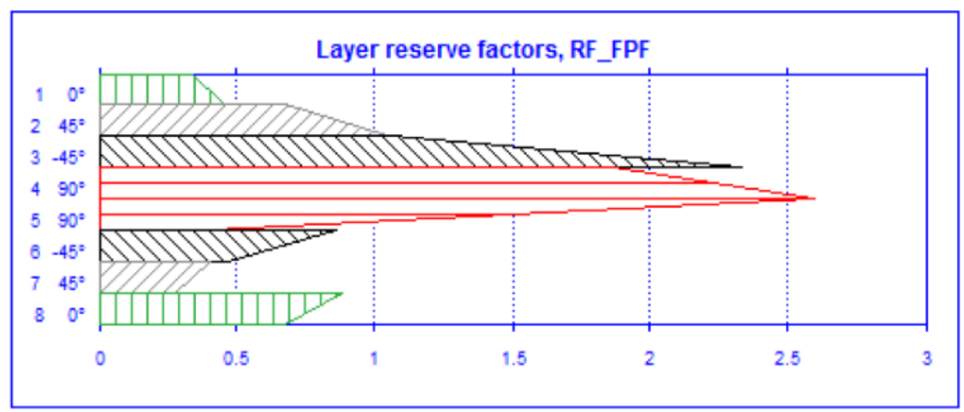
$$E_x = \frac{A_{11}A_{22} - A_{12}^2}{h\, A_{22}}$$

Résistance des matériaux composites





$$\begin{bmatrix} N \\ M \end{bmatrix} = \begin{bmatrix} A & B \\ B & D \end{bmatrix} \begin{bmatrix} \varepsilon^0 \\ \kappa \end{bmatrix}$$



? propriétés des anisotropes

Comment calculer le module transverse
d'un composite unidirectionnel ?

Comment se déforme un stratifié
sous l'effet d'un moment de flexion ?

Pourquoi les contraintes sont différentes
dans chaque pli d'un stratifié ?

Comment augmenter un Reserve Factor ?

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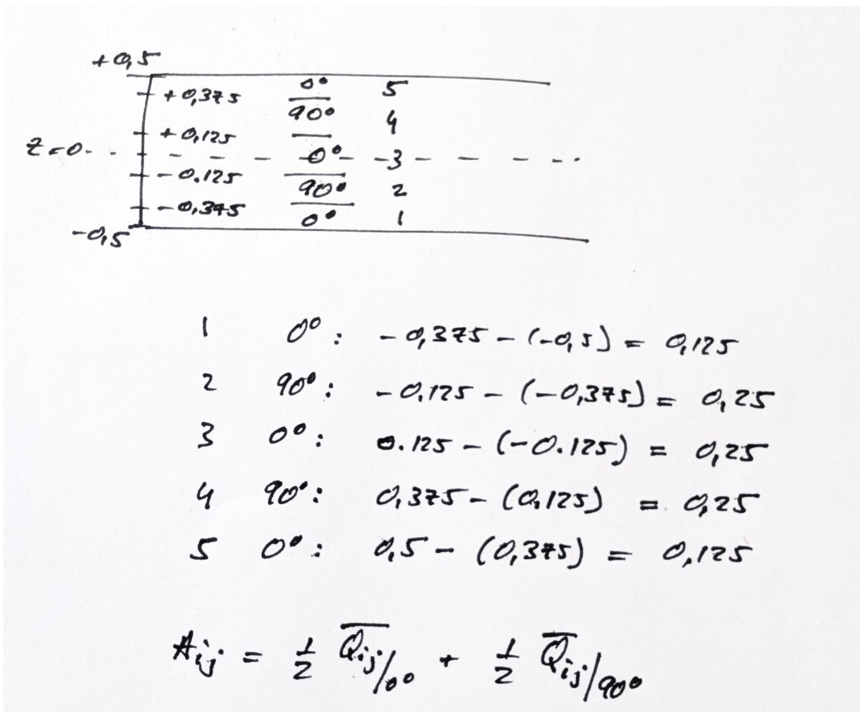
Exercices

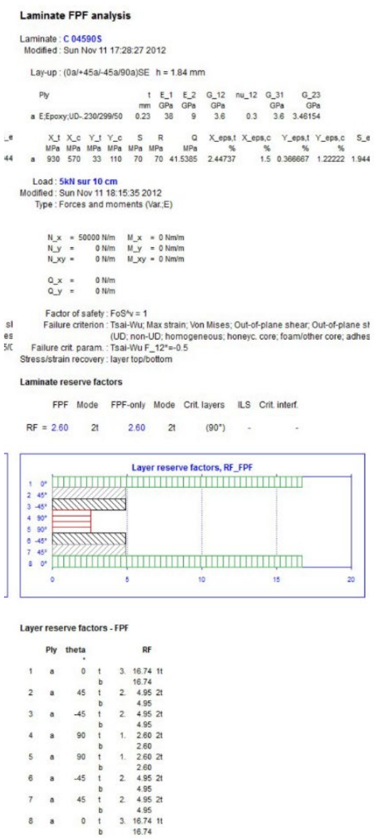
Exo7: en augmentant le nombre de strates, A ne change pas, B diminue. Calculs avec des épaisseurs égales des plis,
? quid si avec des plis d'épaisseurs différentes

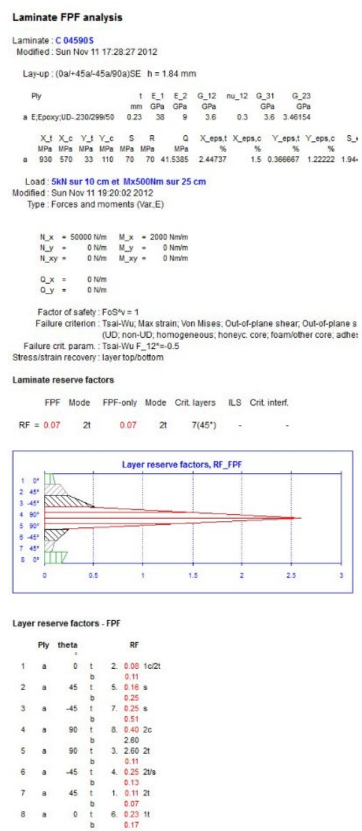


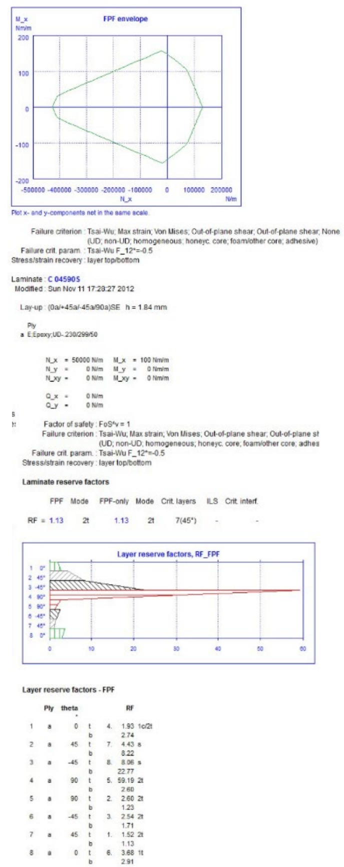
Exercices

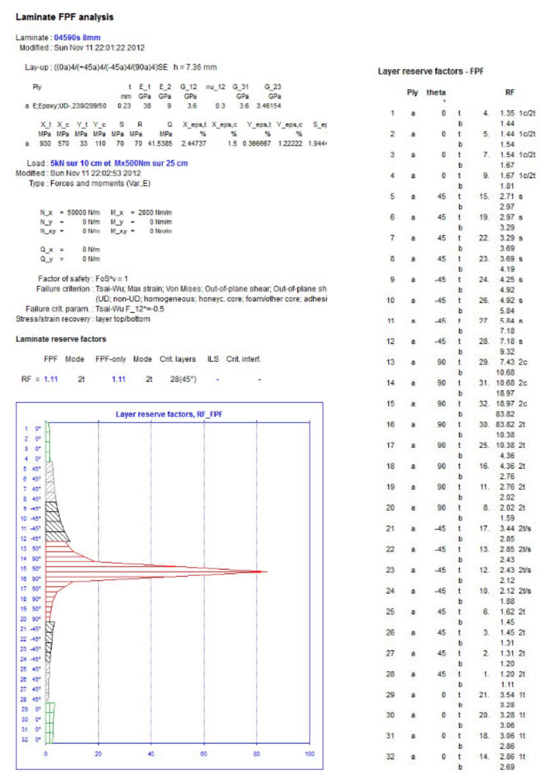
Cours MSE 340 Composites Polymères 2025, Exo B avec ESACOMP : résistances, critères de rupture **Exemples de déterminations de la rupture du premier pli et de l'optimisation des facteurs de réserve pour éviter les ruptures.**

La même approche est utilisée pour valider vos choix de matériaux et de structure du stratifié pour votre bouteille sous pression et votre snowboard.









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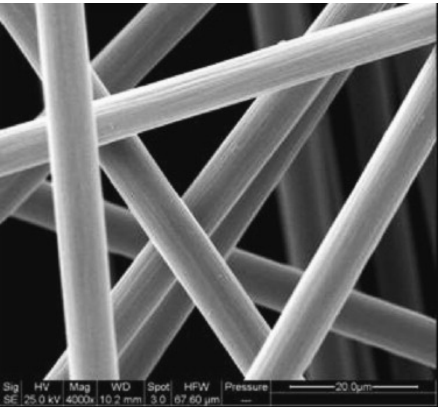
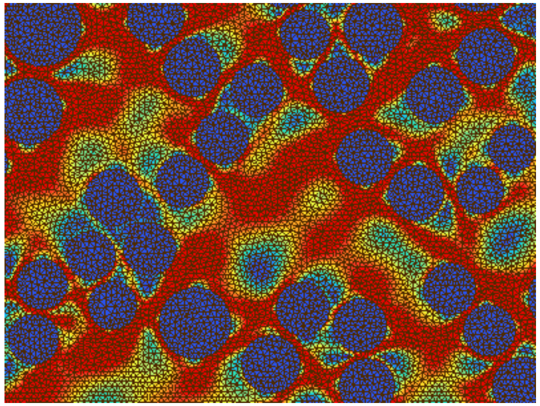
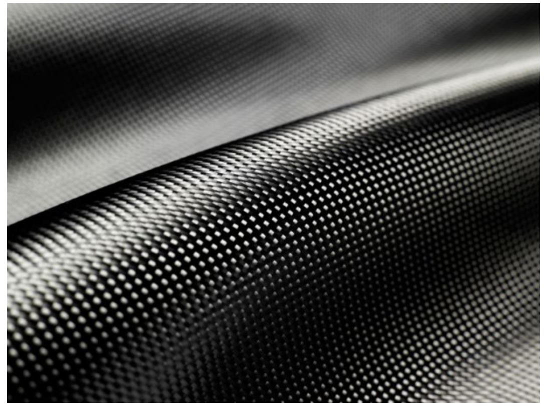
www……composites…..



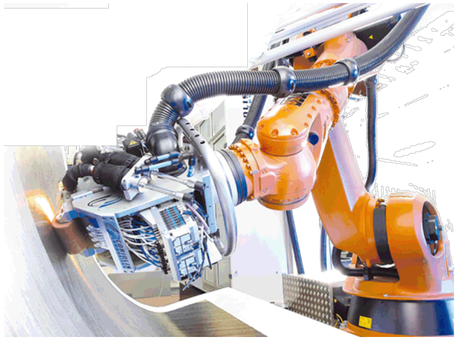
www.reinforcedplastics.com



www.onera.fr



blog.motorlegend.com



www.coriolis-composites.com

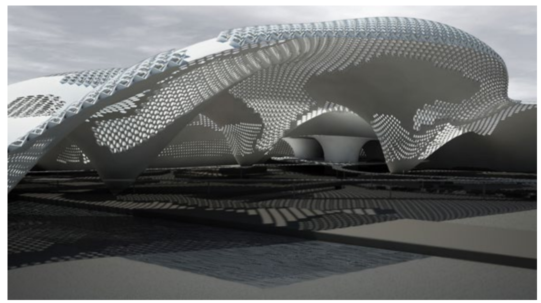
Boeing

BMW i8 automobile.challenges

www.decision.ch

Samsonite zedomax.com

Hublot



www.evolo.us

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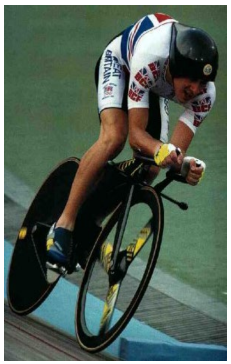
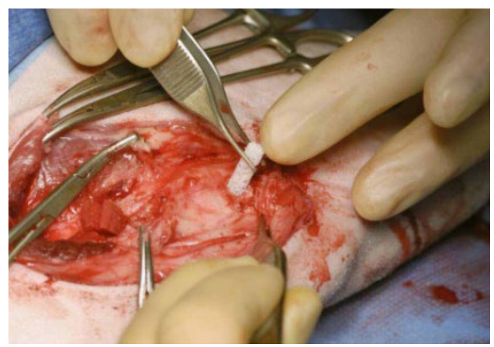
Composite materials?







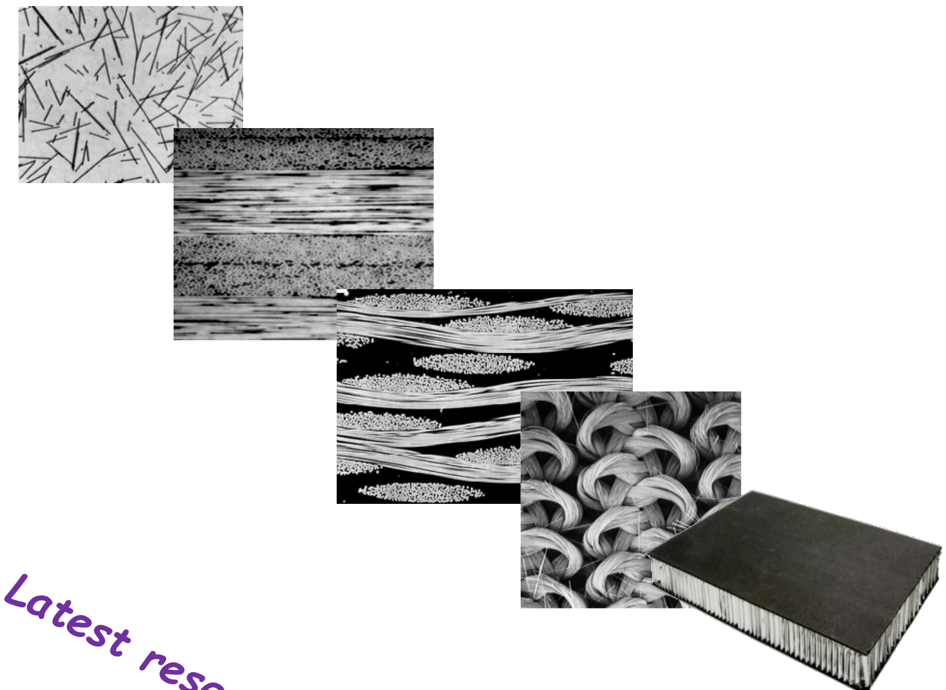


Your composite product…

Ready for the future…

- Introduction aux composites
- Constituants
- Théorie et procédés de mise en œuvre
- Micromécanique, Macromécanique
- Illustrations de choix de matériaux, de mise en œuvre, de conception…
- Quelques principes de recyclage
- Exercises

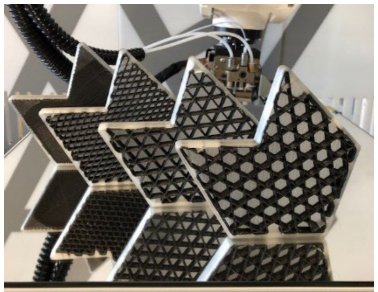
- Bases pour le cours MSE 440 de Master
  - Sandwich structures and textiles composites
  - Structural design and joining with composites
  - Towards sustainable composites
  - Biocomposites for biomed, sport…
  - Cost modelling-a tool for sustainable innovation
  - Smart composites
  - Nanocomposites



Latest research, innovation and…
…your composite products

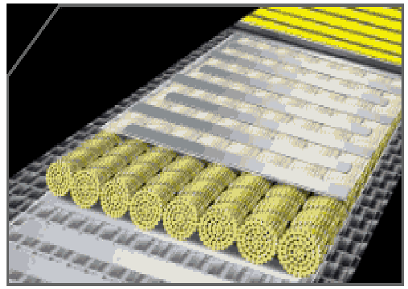
R&D&A

3D printing



Anisoprint

Functional composites

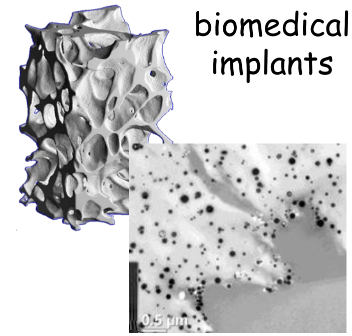


Biocomposites

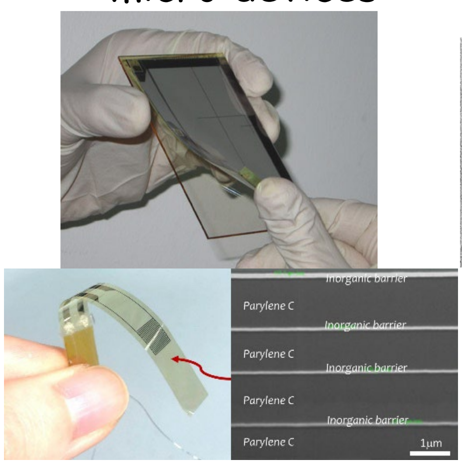
Natural fibres composites

https://www.bcomp.ch/

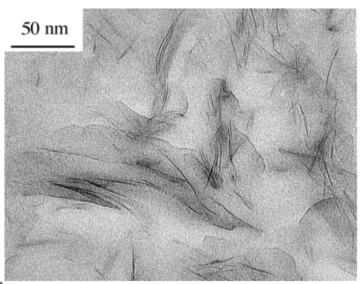
Resorbable biomedical implants



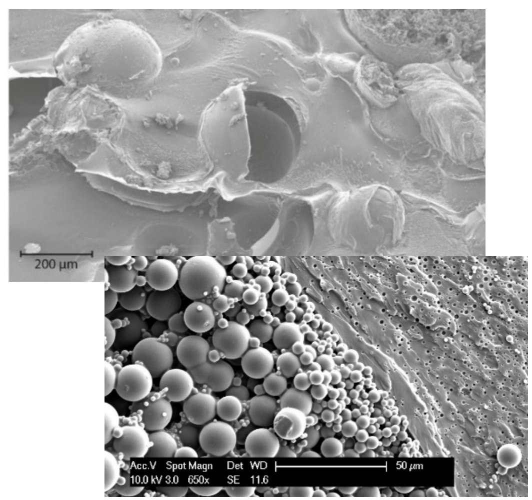
Thin films and micro devices



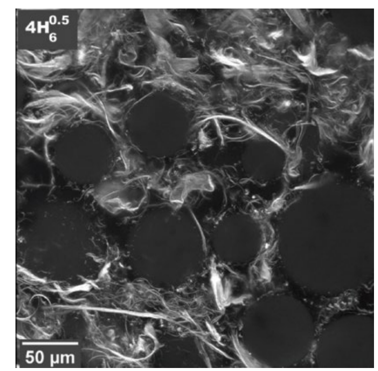
Nanocomposites



Self-healing composites



Hydrogel composites

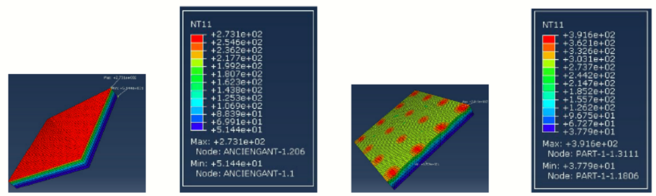


Your composite product…

Masters-2022

Durable smartphone case made of recycled composites

The temperature elevation for a heat flux of 10,000 W/m^2 during 30s was recorded. The result obtained on our glove is shown in Figures 3c and 3d and is compared to the initial Formula 1 glove in Figures 3a and 3b below.



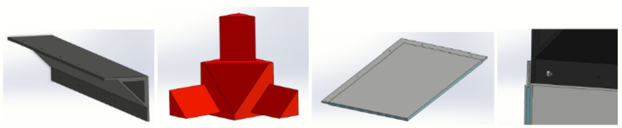
(a) Visual result (b) Scale table (c) New Visual result (d) New Scale table

Figure 3: Results of the Abaqus simulation for a reference fabric and for the new product

Composite photovoltaic blinds

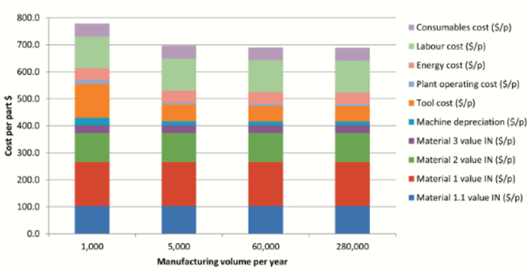
Composite technologies– MSE-440 –Team 5

Ecofriendly shelters



(a) Design of the structural beam (b) Design of the connector part (c) Design of the panel (d) Design of M8 holes

Figure 1: Design of main elements of the house



Piezochromatic composite in hydrogen pressure vessels

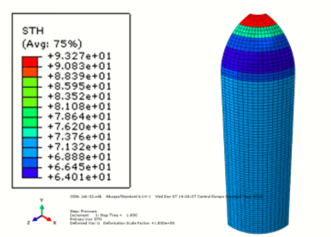


Figure 5. Final thicknesses of fibers on the pressure vessel [mm].

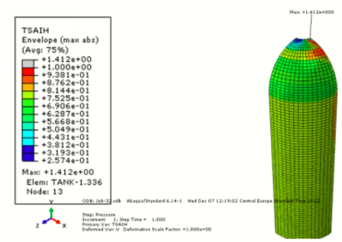


Figure 6. Tsai Hill Failure criterion for envelope and weakest ply.

Composite Greenhouse

Figure 5: 3D views of the greenhouse structure design

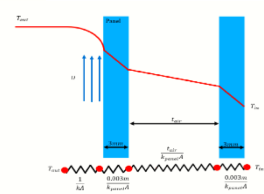


Figure 1: Sketch of the double glazing case. There is only convection outside and conduction inside the panel and in the air trapped between the two panels. Between these panels, convection is neglected because the system is airtight

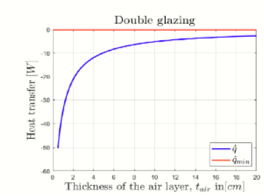


Figure 2: Heat transfer in function of the thick ness of the air layer between the two panels. Th red line represent the minimum heat transfer.

Ergonomic air tank

Fig. 1. Pressurized ergonomic portable compressed air tank

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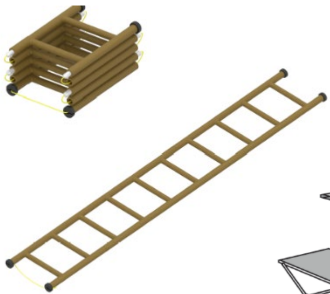
Your composite product…

Masters-2023

Composite ladder



Camping kit

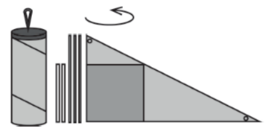


Figure 1: Sketch kit folded

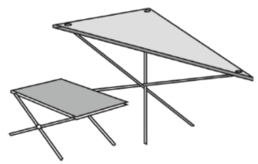
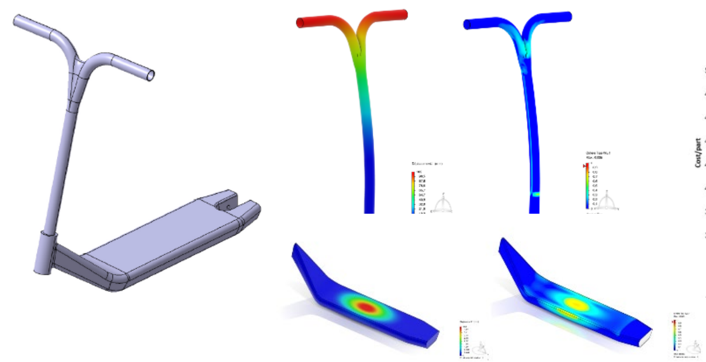
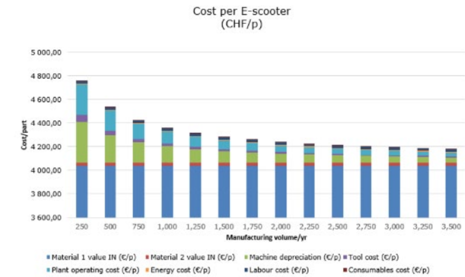


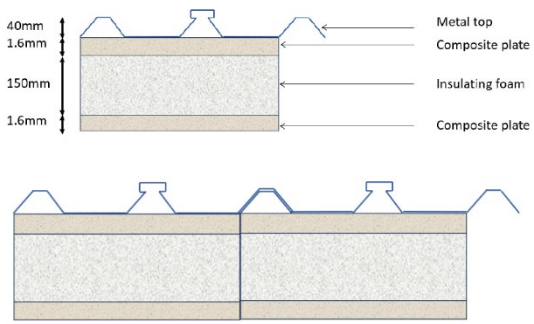
Figure 2: Sketch kit unfolded

Rental Electric Scooter - Flax fibers deck & steering pole

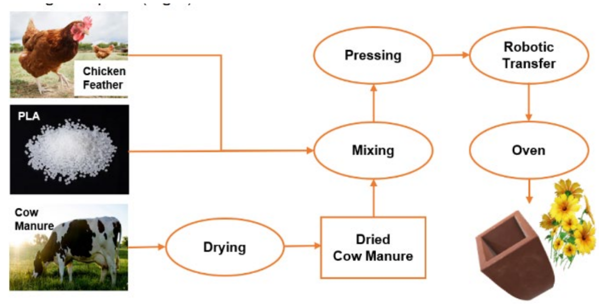




Roof panels



Biodegradable flower pots



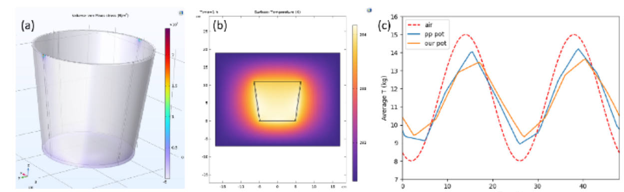
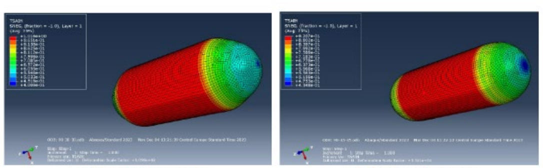


Figure 1. (a) The loading test on flower pots. (b) Time-dependent thermal simulation setup. (c) Temperature variance in the center of the pot during 2 days. The red dash line is the reference air temperature in the environment where the flower pot is put.

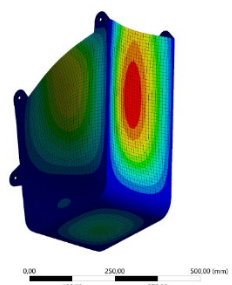
Oxygen cylinders



(A) (90/30/-30) orientation

(B) (90/45/-45) orientation

Battery tray for electric motorcycle



Composite longboard

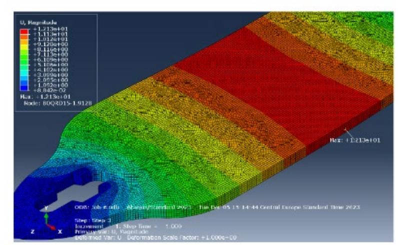


Figure 3: Deflection of the board under load

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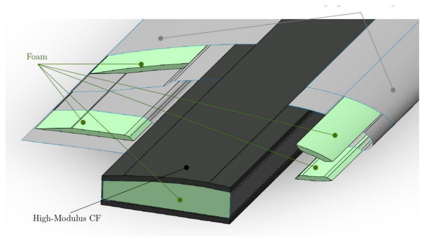
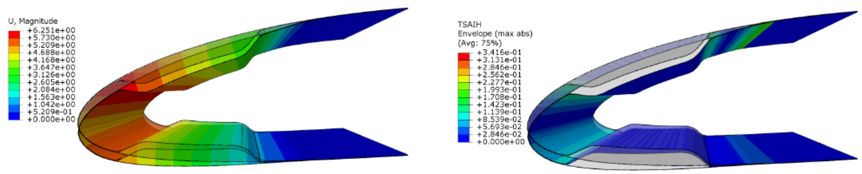
Your composite product...

Masters-2025



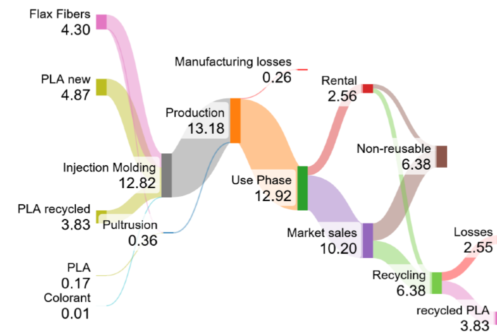
Morphing wing



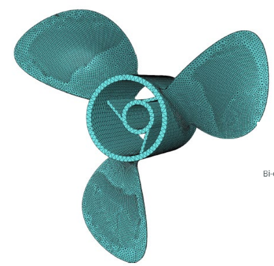
(a) Displacement (b) Tsai-Hill failure criterion

Mussel composites

Material flow for tent pegs

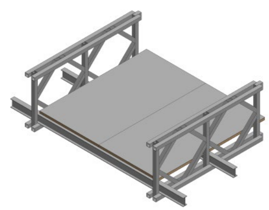


Boat propeller

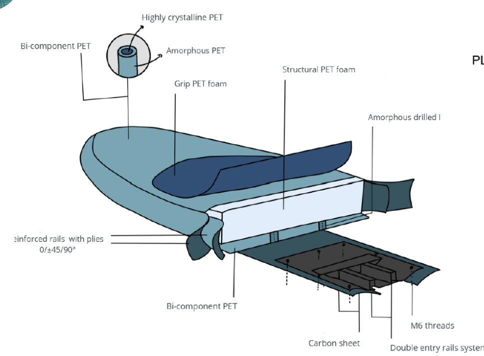


Adaptive thermoformable cast

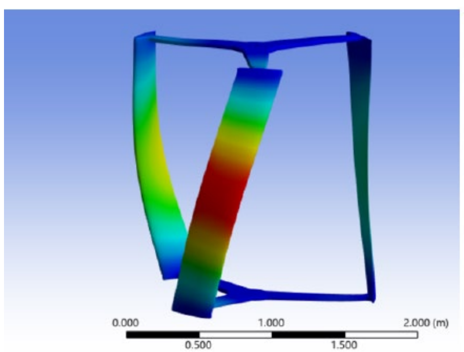
Portable bridge



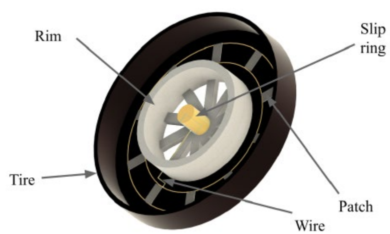
Fully recyclable wingfoil



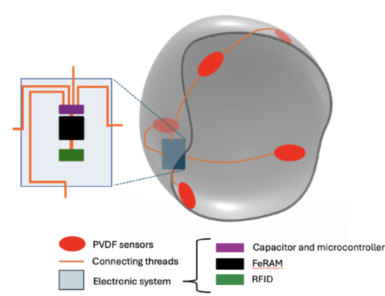
Turbine blade for tidal power generation



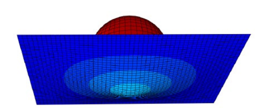
Smart tires

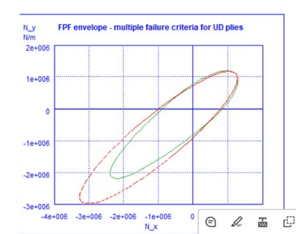


Smart Helmet



Self healing boat hull





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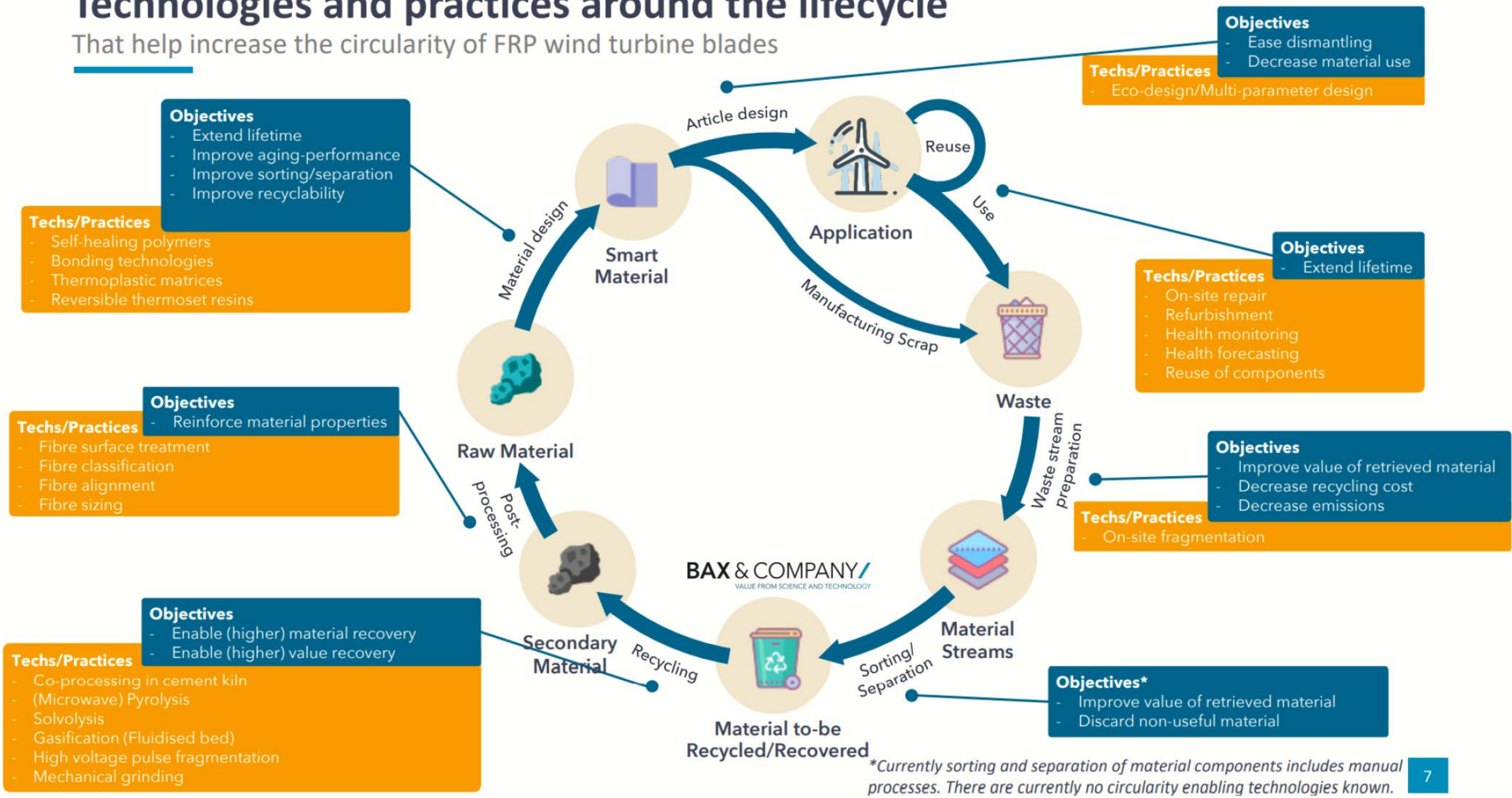
Technologies and practices around the lifecycle

That help increase the circularity of FRP wind turbine blades



Examen

- MSE 340 Composites: 1/3 TP + 2/3 examen
- Oral le 26, 27, 28 janvier
- 5 min de préparation et 15 minutes de réponses
- 3 questions: Constituants/Mise en œuvre/Mécanique

- Liste de passage (Moodle, fichier partagé…)

https://docs.google.com/spreadsheets/d/1AdceYzxcfnBBv2dMmMsSmPywlx7BwzG7KMQ8y7OKWUA/edit?gid=0#gid=0

- Révision : le résumé, les exos, les questions