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Development of Melt Thermoplastic Resin Transfer Moulding

Damiano Salvatori, Sara Dalle Vacche, Maxime Cattin, Véronique Michaud, Laboratoire de Technologie des Composites et Polymères (LTC), EPFL

OBJECTIVES

- Develop and optimize a novel impregnation process to make thermoplastic composite parts which could replace structural metallic parts in cars in a cost-effective way
- Minimize impregnation time for high-volume production

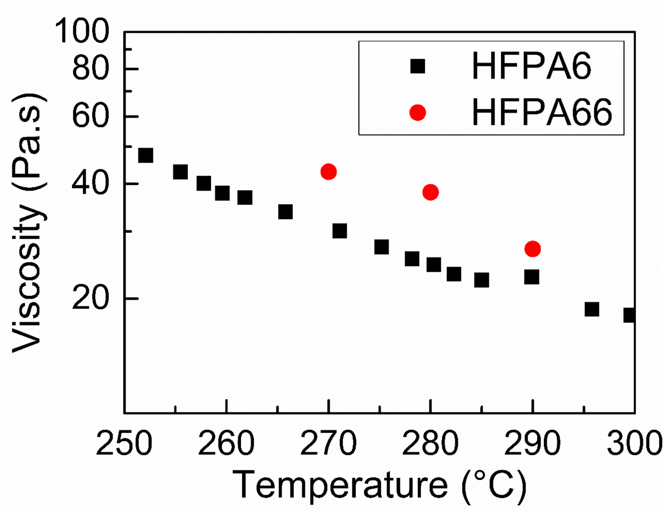
CURRENT RESULTS

- Conception of a novel RTM tool
- Characterization of a low viscosity Polyamide grade
- Successful impregnation of small parts
- Issues identified: fibers displacement, air entrapment, polymer leakage

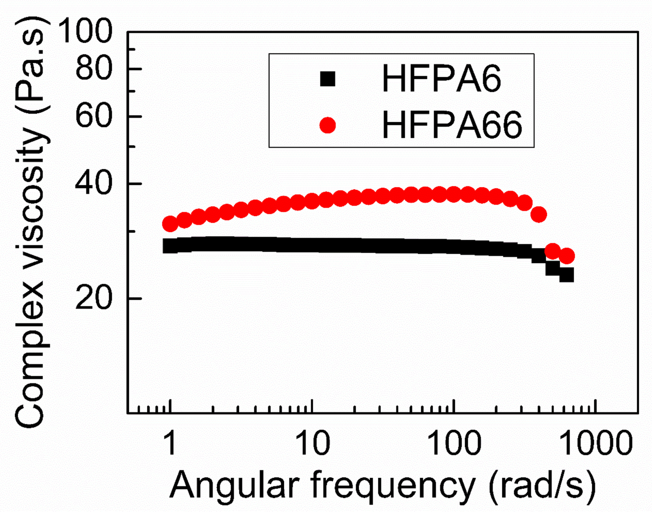
MATERIALS

Matrix: high-fluidity polyamides 6 and 66

High fluidity allows in-plane fabric impregnation
Behave as Newtonian fluids in Resin Transfer Moulding (RTM) process conditions

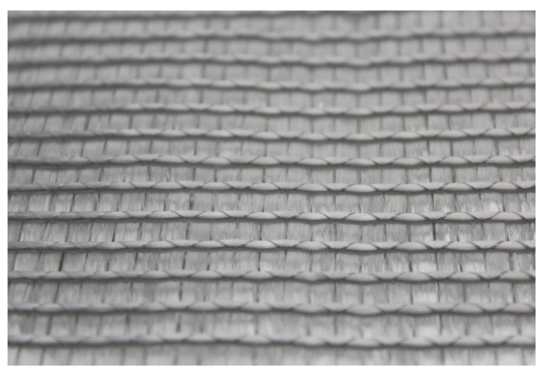


Melt-viscosity measured in flow-mode in the Newtonian range on a plate-plate rheometer



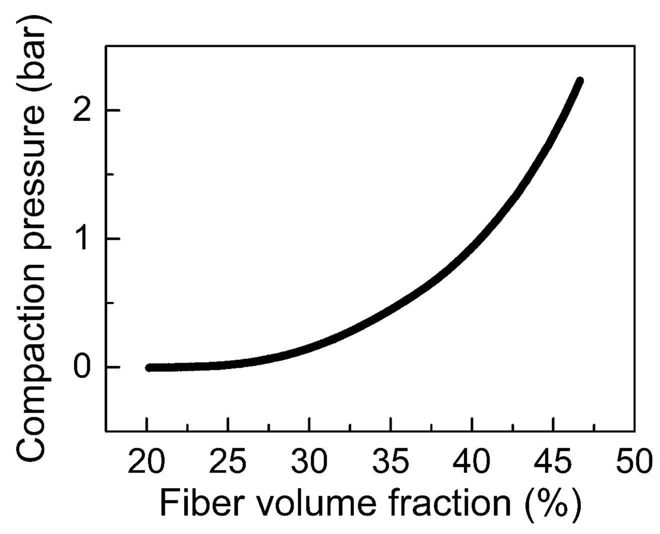
Complex viscosity measured in oscillation-mode as a function of frequency on a plate-plate rheometer

Fabric: non-crimp glass fabric 'G-Ply' (720 g/m^2) from *Chomarat*



Longitudinal tows bound by polyester stitch resulting in high permeability
In-plane permeability, K [0°], for V_f = 0.49
Test-fluid: aqueous solution of PEG 5.7 mM (η=0.1 Pa s):

$$K = 1.3 \pm 0.2\ 10^{-9}\ m^2$$

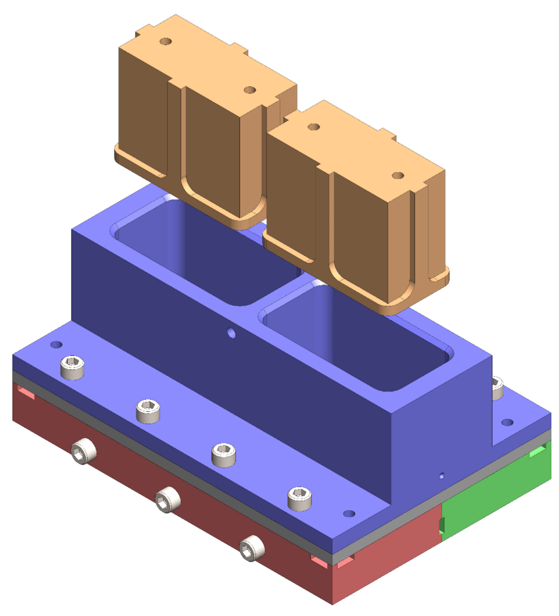


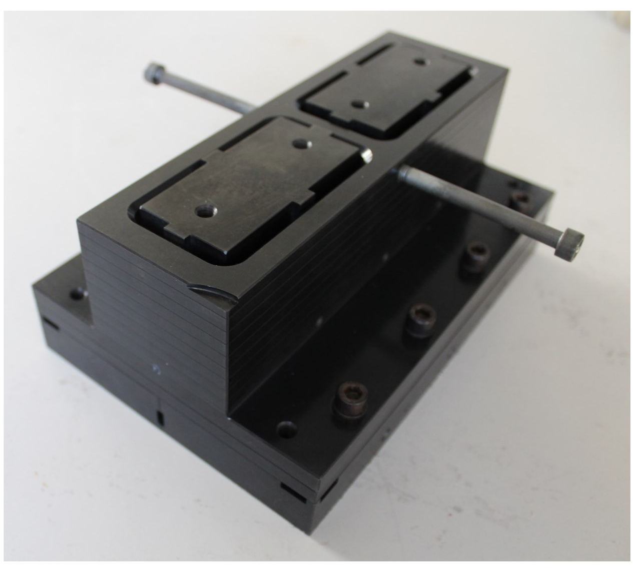
Compaction curve of the G-Ply measured on a mechanical testing machine
Gives the pressure necessary to compact the fabric in a mould of given thickness

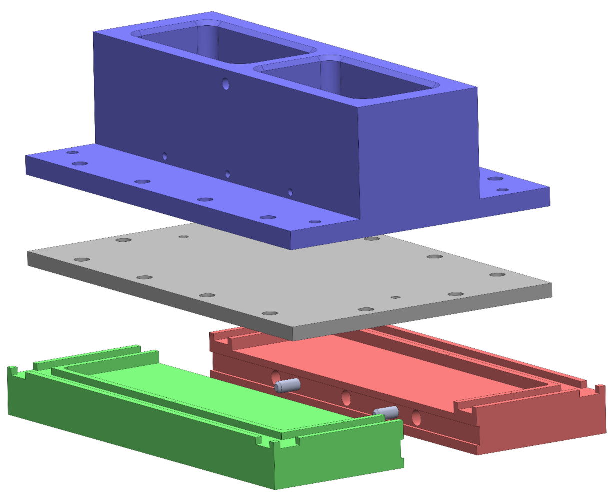
PROCESS

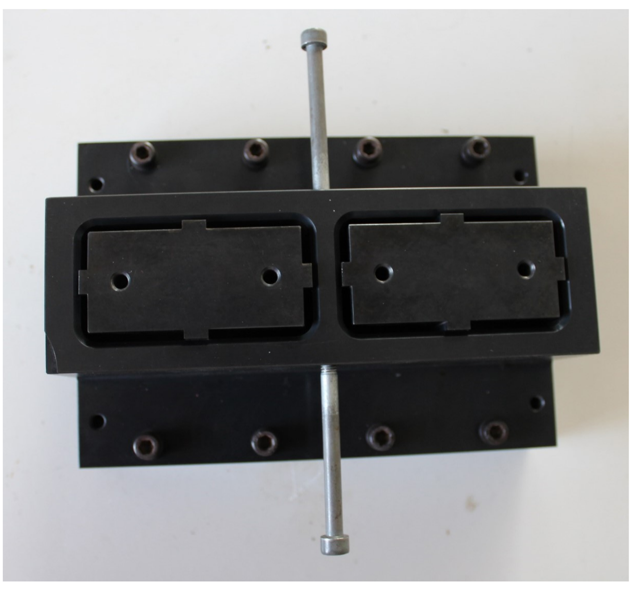
Melt Thermoplastic RTM tool

A novel tool has been designed to obtain thermoplastic composites through in-plane melt impregnation.
The polymer pellets are placed in the melting pots.
A constant pressure applied at the pistons transfers the melt through a hole in the underlying cavity containing the fabric.
Impregnation by two sides is also possible.









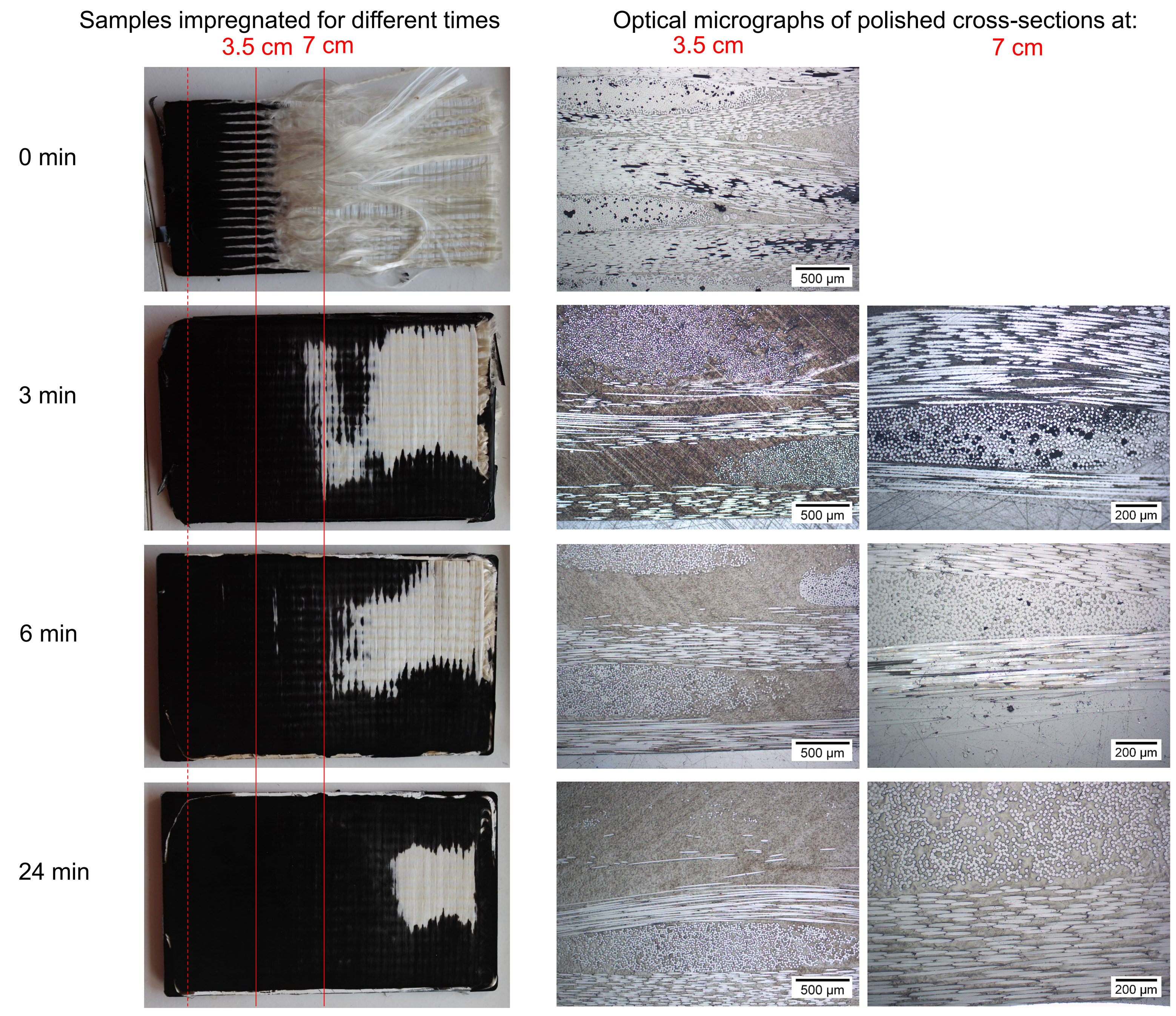
First trials of in-plane melt impregnation

Impregnation temperature = 280°C, fluid pressure = 20 bar, fiber volume fractions = 0.49

Impregnation time (t) for uni-directional impregnation under constant pressure from Darcy's law:

$$t = -\frac{L^2 \eta (1 - V_f)}{2K\Delta P}$$

➢ Need to consider capillary effects, micro-impregnation effects, non-constant viscosity, air escape



OUTLOOK

- Propose improved permeability preforms
- Use alternative low-viscosity polymers
- Test mechanical and thermal properties
- Model impregnation time considering capillary effects

Laboratoire de Technologie de Composites et Polymères (LTC)
EPFL-STI-IMX-LTC
Station 12
CH-1015 Lausanne
ltc.epfl.ch

LTC LABORATOIRE DE TECHNOLOGIE DES COMPOSITES ET POLYMERES

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