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Numerical Modelling of Molding Compression Of Fibre-Reinforced Composites for Industrial applications

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► **To cite this version:**

Patrice Laure, Luis Fernando Salazar Betancourt, Luisa Silva, Mustafa Sager. Numerical Modelling of Molding Compression Of Fibre-Reinforced Composites for Industrial applications. 10th Annual European Rheology Conference (AERC 2015), Apr 2015, Nantes, France. . hal-01285046

HAL Id: hal-01285046

<https://hal.science/hal-01285046v1>

Submitted on 8 Mar 2016

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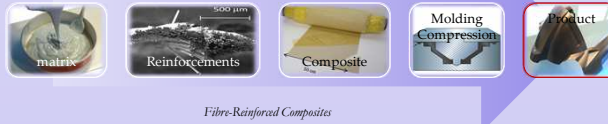
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Abstract

A transverse isotropic viscous model accounting for the anisotropy exhibited in fiber-reinforced composites is integrated in the numerical platform of the software Rem3D®. Simulations under various mechanical loadings are tested for volume fiber concentrations of 3.5% and 14.7%. Equivalent stresses and equivalent strain rate deformations given by the software were compared to the ones coming from experimental data, finding very good agreements. As a second point developed on this paper, we comment on the slip condition between Die/Punch tool with the composite under compression. We noticed that the variation of the viscosity value on a small layer between the Die/Punch tool and the composite affects the nature of the contact. A viscous friction is then formulated as a technique to set slip/no-slip contact conditions. We found that the slip condition is recovered at lower values of the viscosity in the interface Die/Punch with the reinforced composite, whereas the no slip condition stated for higher viscosity values.

Process and Industrial Application



high performance and low density

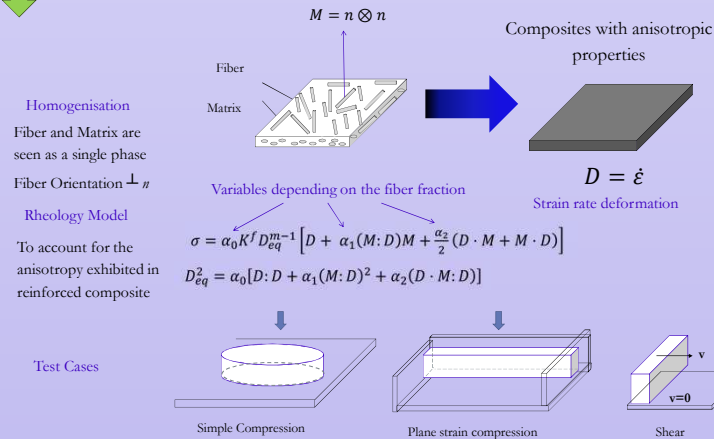


Automotive: 10% weight reduction compared to all-aluminium design



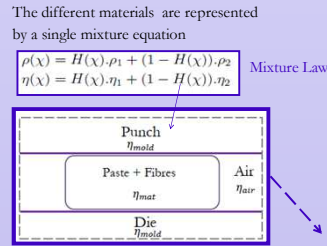
Renewable Energy components

Rheological Behaviour of SMC under Compression

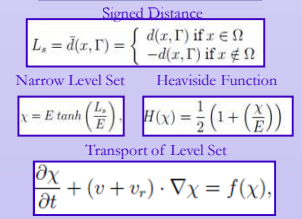


Immersed Method

[Coupez et al. 2010]

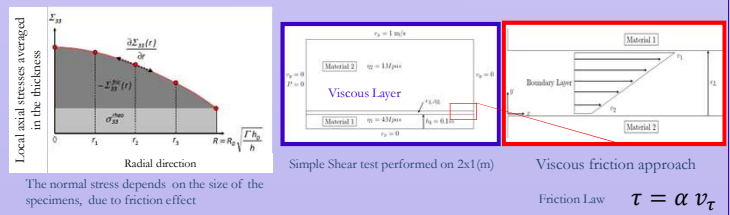


Level Set Method



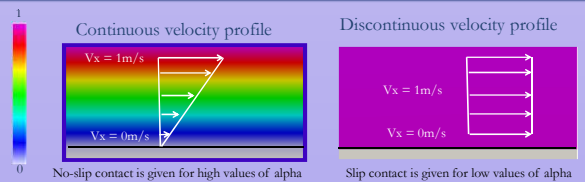
By solving the multiphase FE resolution, we obtain the solution of each domain

Friction Modeling

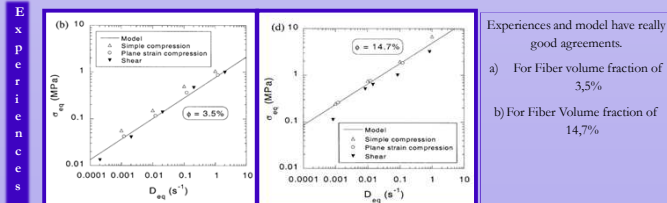


In our immersed domain, we insert a layer assigned with a thickness and a viscosity. These two factors enable the setting of a friction coefficient.

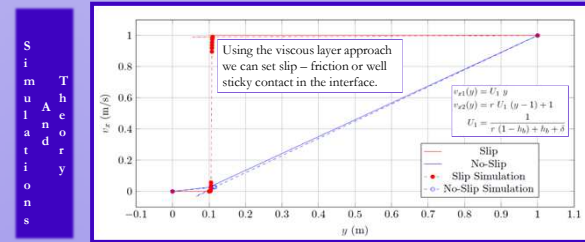
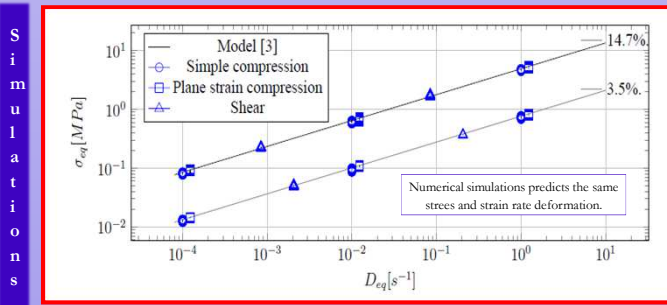
Numerical difficulty: obtaining a discontinuous velocity profile in an immersed volume method with mesh adaptation and automatic remeshing



Comparison Model with Experiences [Dumont et al. 2003]

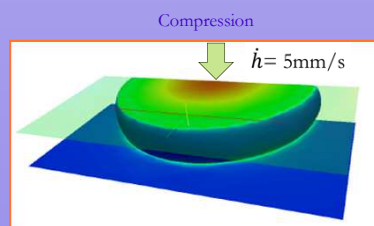


Comparison Model with Numerical Simulations [Salazar et al. 2015]

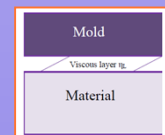


- Compression of fiber material with 14,7% weight fiber concentration.
- Friction coefficient has been set. $e_L = 2 \cdot 10^{-4}$

Compression with friction



Viscous Layer is used to set the lubrication condition in the interface Mold/Composite



Numerical Resolution: Rheological Model for Reinforced Fibre composites is used to described the mechanics

Conservative equations

$$\left\{ \begin{array}{l} \nabla \cdot (2 \eta_v D(v^{i+1}) + \sigma_s(v^{i+1})) - \nabla p^{i+1} = 0 \\ \nabla \cdot v^{i+1} \\ + B.C \end{array} \right.$$

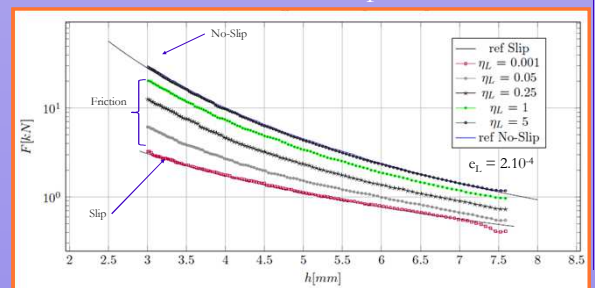
$$\Rightarrow (v^{i+1}, p^{i+1}) \rightarrow \eta_{v+1}$$

Transport Equation

$$\frac{\partial \chi^{i+1}}{\partial t} + (v^{i+1} + v_r^{i+1}) \cdot \nabla \chi^{i+1} = f(\chi^i)$$

$$\Rightarrow (\chi^{i+1})$$

Friction effect on the compression force



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