Simulation of Resin Impregnation, Heat-Transfer and Cure in a Resin-Injection Pultrusion Process

Michael Sandberg[1, a)], Filip Salling Rasmussen[1], Jesper H. Hattel[1], Jon Spangenberg[1]

[1]Produktionstorvet Building 425, DK-2800 Kgs. Lyngby, Department of Mechanical Engineering, Technical University of Denmark

[a)]Corresponding author: misan@mek.dtu.dk

Abstract:
Resin injection pultrusion (RIP) is a continuous process for the manufacture of composite profiles with a constant cross-section. In RIP, the fibre material is pulled through an impregnation chamber directly followed by a heating die. In the impregnation chamber, the fibre material is wetted by means of resin injection and in the heating die an exothermic curing reaction is initiated. RIP is a closed mould process, whereby visual inspections and experimental measurements are difficult or impossible to conduct. This limits hands-on process optimisations to a level where the implications and sensitivities of different process parameters are unknown. Numerical simulations of RIP processes are thus of high importance.

In the present study, a numerical framework for the multi-physical simulation of the interaction of resin flow [1], heat-transfer and the curing kinetics [2] in a resin-injection pultrusion process is considered. The flow model follows Darcy's law for flow in porous media, and the development in flow front location is tracked with a level set method [3]. The framework is based on the Finite volume method, developed in a 2D in-house code.

Using the numerical model, it is demonstrated how the resin-impregnation, i.e. the stationary flow front position and the distribution of pressure in the impregnation chamber, is affected by the temperature and cure-dependent rheology (solidification) of the resin (Figure 1).

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[2] Baran, I., Hattel, J. H. and Tutum, C. C. (2013) 'Thermo-chemical modelling strategies for the pultrusion process', *Applied Composite Materials*, 20(6), pp. 1247–1263.
[3] Fu, L., Hu, X. Y. and Adams, N. A. (2017) 'Single-step reinitialization and extending algorithms for level-set based multi-phase flow simulations', Computer Physics Communications. Elsevier B.V., 221, pp. 63–80.

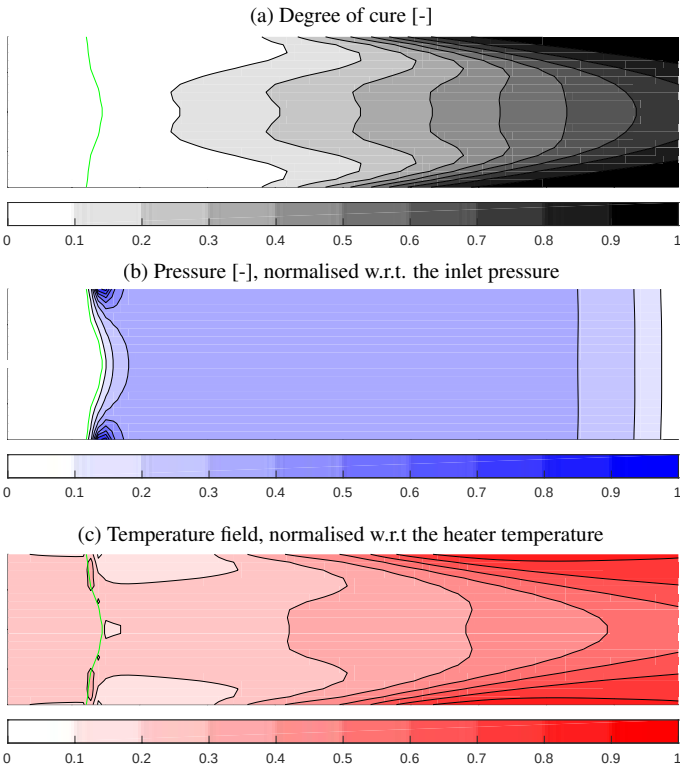

Figure 1: The degree of cure, pressure and temperature field in a resin-injection pultrusion process. The green line indicates the flow front position.