ADVANCED COMPUTATIONAL STRATEGIES FOR FAST AND RELIABLE GATE ARRANGEMENT PRE-DESIGN OF RESIN INFUSION PROCESSES

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Introduction

Resin Infusion (RI) process is frequently used for large composite parts production. This Liquid Composite Molding method uses vacuum pressure to shape a plastic bag as a counter mold. Once a complete vacuum is achieved, the resin is sucked into a dry preform textile laminate via placed tubing. Mold filling strategy can be based on the continuous deformation of the vent-oriented flow pattern due to the driving pressure from the inlet gate. One of the main objectives is that the resin flow achieves the vent gate uniformly to avoid pressure drop and ensuring complete filling. In RI, the flow front shape progression is mainly conditioned by the initial arrangement of the injection and vent gate line allocations and the permeability of the preform that can evolve along the flow path.

The main awareness of this research [1],[4] is to develop computational tools that should be based on the geometry of the flow path trough the mold filling. A suitable assumption of flow front's shapes constrained by RI process can be based on that the *flow front filling time can be related to the distance* of the flow path from the inlet to the outlet gate [2],[3].

A Fast Marching-Level Sets approach for the distance field computation

In this work is proposed a RI flow pattern modeling approach based on considering a distance field computation as the flow front evolution in order to have a pre-design numerical tool for an appropriate simulation based process definition. This technique treats the resin flow front in a simplified manner that allows one to use it as a design tool to predict the flow behaviour in different prescribed process and material conditions. A fast marching - level set approach [1] is used to model non-physically the different alternatives of the front shape evolution during filling as the zero set of an implicit function ϕ . In [1] is presented the technique for a suitable use in the numerical treatment of the advancing resin front as a distance field evolution. The evolution of this implicit function under an external velocity field can be written as

$$\phi_t + v \cdot \nabla\phi = 0 \tag{1}$$

where, sub-index indicate a partial derivative with respect to that variable. We assume that the velocity field at the flow front is normal to the implicit function ϕ itself, $v = V_n n$ with V_n constant and ϕ is defined as a signed distance function, i.e., $|\nabla\phi| = 1$.

See [5] for details on the discretization of these equations. The front interface is defined computing the implicit function $\phi^n = 0$ from (1) for a given instant *n*. One can now define different geometric operators for the whole domain (instead of just a contour front) such is *Distance Pattern function* Θ, defined as the accumulative distance flow front evolution and its *Laplacian* Λ, used here as geometric definition of equidistance flow to a given location:

$$\Theta = \sum_{n=1}^{n} \phi^n$$
$$\Lambda = \left(\Theta_{xx} + \Theta_{yy}\right) \tag{2}$$

Application in the Resin Infusion gate arrangement pre-design

In order to show the capabilities of the procedure, we work out different examples. In the case shown in Figure 1, we assume the vent vacuum line is located on the contour of the simple 2D-rectangular part. An interior obstacle (upper right) defines a hole and, in this case, is treated also as vent line. Moreover, the part has two discontinuous regions of different permeability (middle left band permeability is double) that yields complex flow advancement. The numerical procedure iterates different options searching a continuous connected injection gate arrangement preserving the RI assumptions. Sequential fillings can be also computed instead of a 'one shoot' filling strategy. These pre-design solutions can be later used to simulate with a FEM-CV approach [6] the resin flow pattern and filling time evolution.

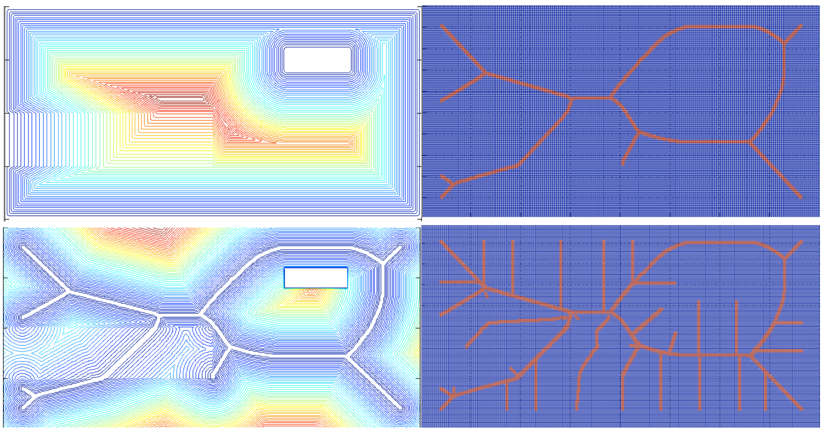

Figure 1: *(**Upper-Left**, Distance Pattern function Θ Inwards from the vent lines; **Upper-Right**, First iteration, Injection Line obtained with Laplacian Λ, **Lower-Left**, First iteration, Distance Pattern function Θ Outwards from the injection lines; **Lower-Right**, Fourth iteration Injection Line obtained with Distance Pattern function Θ Outwards and Laplacian Λ .*

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