FLOW MANIPULATION AND CONTROL FOR VACUUM INFUSION

Justin B. Alms, James L. Glancey (PhD), and Suresh G. Advani (PhD)

University of Delaware . Center for Composite Materials . Department of Mechanical Engineering

INTRODUCTION

♦Liquid Composite Molding (LCM) is used to create large scale, strong, and affordable structures.

♦LCM involves resin transfer from the injection gates to the vents. During that process the resin must cover all the spaces in between the fibers. Failed infusions are usually due unexpected:

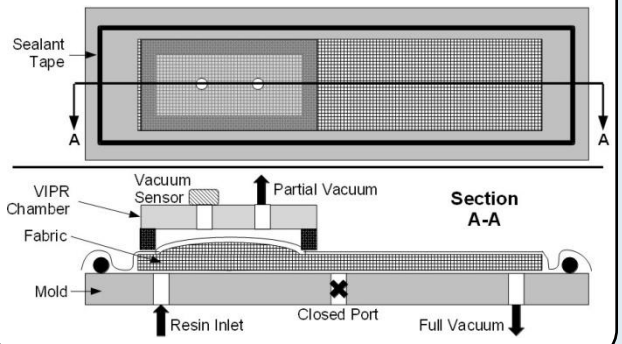
- ✧Race-tracking of resin along mold edges
- ✧Permeability variations within the mold due to mishandling of the fabric.

♦Vacuum Induced Preform Relaxation (VIPR) process has shown the ability to manipulate the resin flow in a controlled and automated setting.

♦Flow methodologies and controllers are developed and validated using a vacuum infusion workstation.

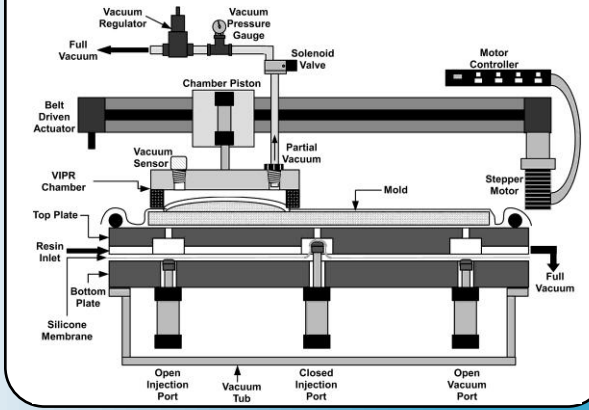
THE VIPR PROCESS

♦The VIPR process uses an external vacuum chamber to relax the fabric in a local region. This action redirects the resin to this region until the external vacuum is maintained thus providing the ability to manipulate the flow.



AUTOMATED VIPR WORKSTATION

♦The VIPR process has been automated to recognize problematic flow fronts and correct them by deploying the chamber and changing injection sites during an infusion.

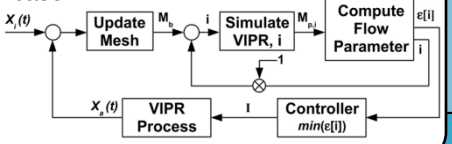


SCENARIO BASED FLOW CONTROL

♦Flow controllers are developed using online flow simulation.

♦Several scenarios are simulated and the best scenario based on the flow front location is selected for execution.

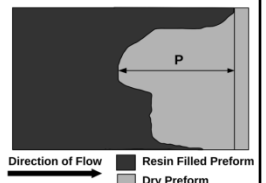
♦The flow parameter, **ε**, quantifies how the flow front deviates from an ideal case.



P & PI CONTROLLERS

♦Traditional flow controllers are adopted and implemented for resin infusion

♦K_P and K_I are tuning parameters.

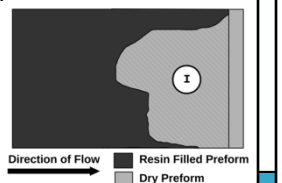


P Control

$\varepsilon(t) = \mathbf{P}$

PI Control

$\varepsilon(t) = K_p\mathbf{P} + (K_I/n) * \mathbf{I}$



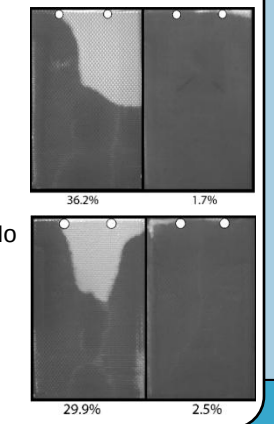
n: number of nodes in perpendicular to the direction of flow in the mesh.

CONTROL vs NO CONTROL

♦Upper Picture: Racetracking on left side. Left: No Control, Right: P Control.

♦Lower Picture: Racetracking on both sides. Left: No Control, Right: P Control.

♦Both cases flow control drastically improved flow.



CONCLUSIONS / FUTURE WORK

♦VIPR process can effectively control resin flow in vacuum infusion processes.

♦Online flow simulation based control is feasible.

♦Develop and test other flow controller designs.

ACKNOWLEDGEMENTS

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