

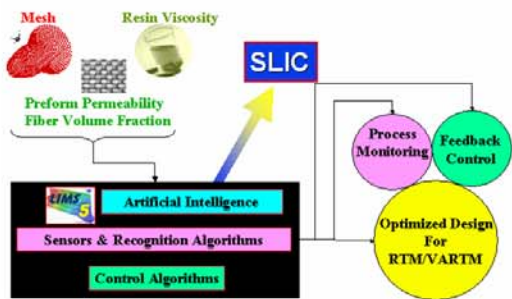
SIMULATION-BASED LIQUID INJECTION CONTROL (SLIC): FEATURES AND APPLICATIONS IN RTM AND VARTM



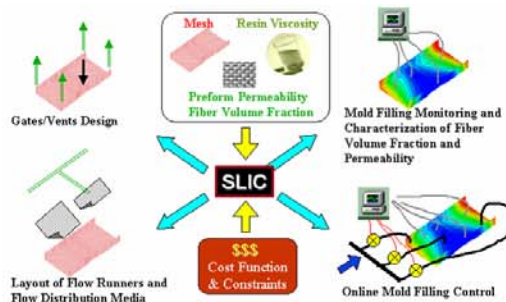
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Simulation-Based Liquid Injection Control: Philosophy



Features of SLIC



Case 1: Optimize Gate and Vent Locations

Input

Length=1.50m
Width=1.00m
Height=0.20m

Thickness = 0.01m
K_{xx} = K_{yy} = 1E-10 m²
Vf=0.5

Resin Viscosity = 0.12 Pa-sec = 120 cps

Injection Pressure = 3.03E+5 Pa
Vent Pressure = 1.01E+5 Pa

Optimized Mold Filling

Injection Gate

Available Features of SLIC	Features Used
Gateway & Vents Design	x
Flow Distribution Network Design	
Mold Filling Monitoring & Online Characterization of Permeability/Volume Fraction	x
Online Mold Filling Flow Control	

Case 2: A VARTM/Co-Cure Case Study

Available Features of SLIC	Features Used
Gateway & Vents Design	x
Flow Distribution Network Design	
Mold Filling Monitoring & Online Characterization of Permeability/Volume Fraction	x
Online Mold Filling Flow Control	

Case 2: Distribution Layer Permeability Measurement with SLIC

Permeability ratio of the distribution layer and the preform is assumed as 5, 10, 15,.....150.

Experiment

Match

12 Experiments were conducted, the permeability ratio was obtained as 20-40.

Case 2: Intuitive (Trial-and-Error) Design vs. SLIC Design

	Dry spot content	Fill time	Number of experiments
Trial-and-error intuitive design	0.851%	10.87 min	4
GA/simulation-based design (SLIC)	0.034%	13.05 min	1

Permeability Variations

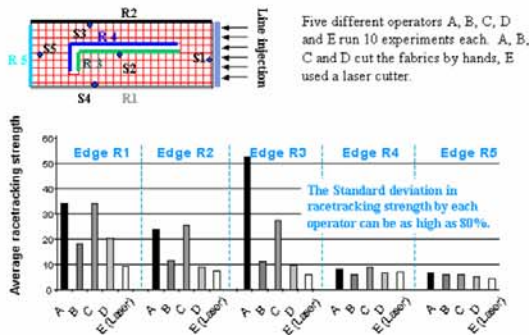
- ✓ Injection Pressure/Port
- ✓ Vent Pressure/Port
- ✓ Resin Viscosity
- ✓ Fiber Volume Fraction
- ✓ Permeability of the Preform

Characterization Challenge!

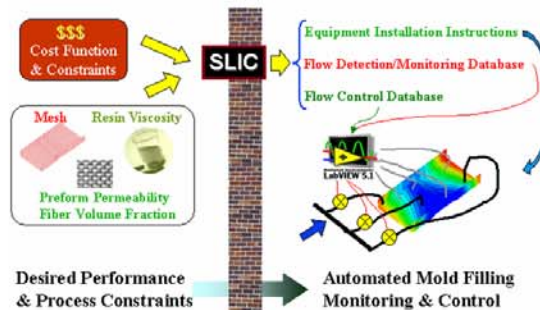
Mold wall
Deformed fabric
Draping over a wet surface

SLIC

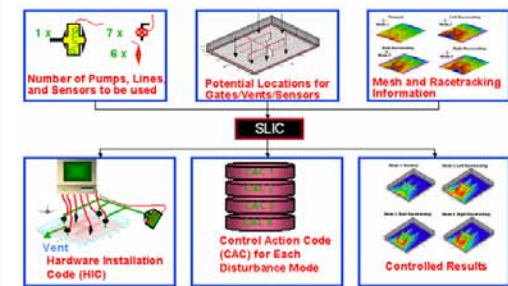
Case 3: Using SLIC to Characterize the Racetracking



Streamlined Flow Monitoring & Control - From Design To Automation



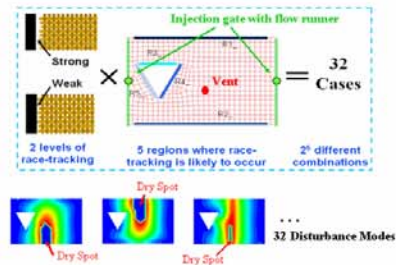
Developing Flow Sensing/Control System with SLIC



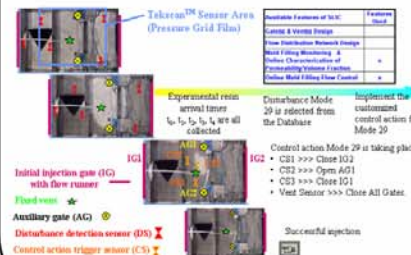
Flow of Automation



Case 4: Online Flow Monitoring/Control with SLIC



Case 4: Online Flow Monitoring & Control with SLIC (Experimental Results)



Summary

SLIC

AUTOMATED DESIGN

- Selection of Initial Gate and Vent Locations
- Optimization of the Flow Distribution Network
- Online Flow Sensing/Permeability Characterization System Design
- Creation of Online Flow Control Solution

Advantages of developing RTM/VARTM with SLIC

- Rapid design for RTM/VARTM.
- Less cost for process development.
- Reliable and comprehensive mold filling solution.
- Advanced flow monitoring/control technology provides the opportunity to elevate the part quality and reduce the cycle time.

ACKNOWLEDGEMENTS

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