# MODELING AND SIMULATION OF AN EXTERNAL VACUUM CHAMBER FOR RESIN FLOW-FRONT CONTROL AND MACRO-VOID REMEDIATION

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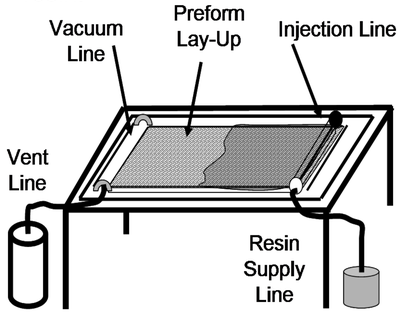
## BACKGROUND & MOTIVATION

Vacuum assisted resin transfer molding (VARTM) is a composite manufacturing process where fibers are placed over a mold, bagged, evacuated of air and injected with resin.




Typical VARTM manufacturing station.

Damaged preform, one of many causes of unpredictable resin flow during infusion.

Composite part with portions of the preform that were not fully infused with resin.

Fibers not infused with resin can form due to variations in permeability, as a result of improper handling of fibers, complex geometries, and variable preform characteristics. Resin starved regions lead to structurally unstable, and therefore defective, parts.

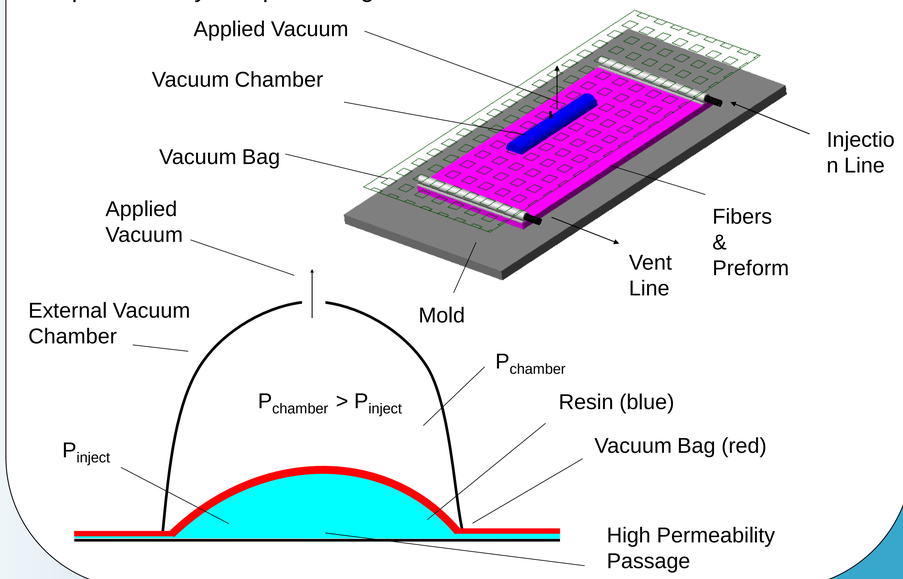
### *Project Objectives*

Design and model flow modification strategies that can provide real-time control of resin flow within the preform during infusion.

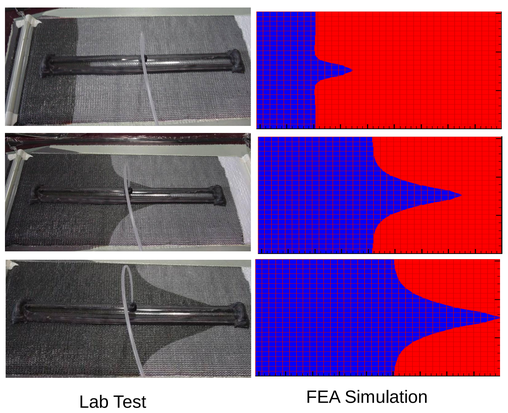
## PROPOSED SOLUTION

***An External Vacuum Chamber for Real-Time Flow Modification***

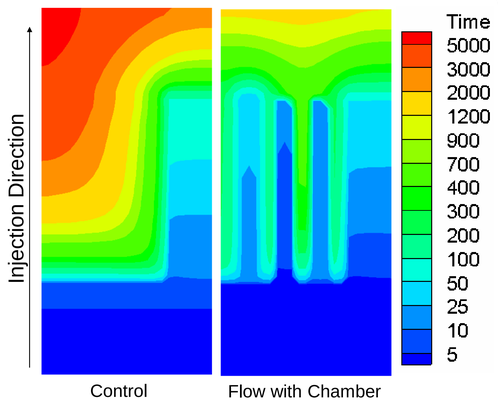
To facilitate resin flow into low permeability regions, a rigid external chamber lifts the vacuum bag during injection thus increasing local permeability and promoting localized resin flow.




## COMPUTER SIMULATIONS



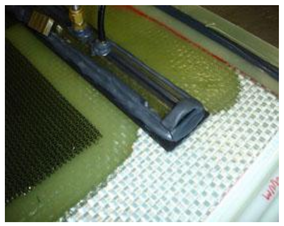

FEA simulations accurately predict effects of the chamber on resin flow.

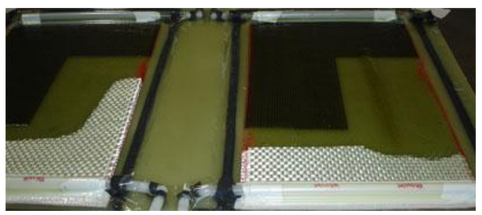



Color contours show dramatic effects on a part with varying permeability in which a chamber has been deployed three times to correct the void. Note that time is in seconds.

## EXPERIMENTAL VALIDATION

Laboratory experiments confirm that a long rectangular external vacuum chamber can remediate regions that would otherwise not fill with resin.





Experimental Control — Modified Flow

## CONCLUSIONS

- An external vacuum chamber has been developed for resin flow front modification and control as a means to prevent dry, unfilled regions within a composite preform.
- This technique can be integrated directly into conventional VARTM and SCRIMP manufacturing methods.
- FEA models accurately predicts resin flow within the mold when using the chamber.
- Computer simulations and lab tests reveal that the external vacuum chamber significantly improves mold filling as well as overall time of injection for a given layout.
- Systems for the automatic detection of flow anomalies and deployment of the chamber are under development.

### ACKNOWLEDGEMENTS

This work is supported by the University of Delaware Undergraduate Research Program and by the Office of Naval Research Advanced Materials Intelligent Processing Center.