AUTOMATION AND FLOW CONTROL METHODOLOGIES TO IMPROVE REPEATABILITY IN VACUUM INFUSION PROCESSES

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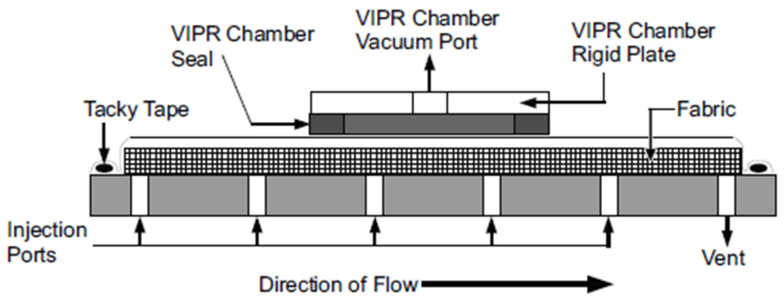
INTRODUCTION/OBJECTIVES

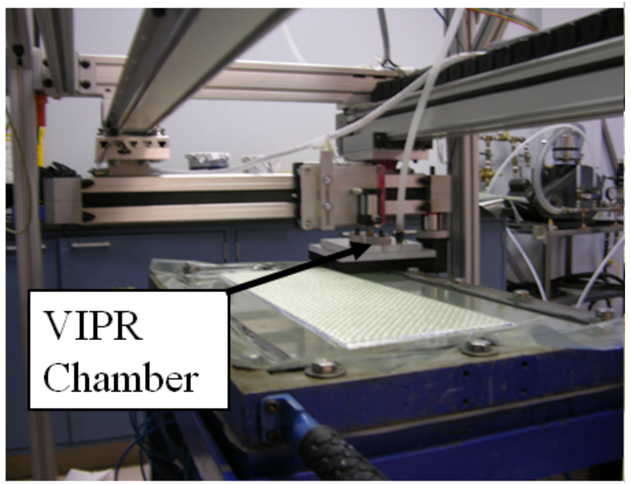
- The VARTM process is used to produce less expensive and highly loaded structures.
- The disadvantage of VARTM processing is the variability naturally inherent in the base materials used in the process.
- To improve repeatability in the process, a new process called Vacuum Induced Preform Relaxation (VIPR) can be used to control the flow of resin.
- Further the VIPR process can be used in an automated fashion to correct unanticipated resin flow behavior using:
  - Complex flow control methodologies
  - Simulation tools which allow the flow controllers to be tuned for superior performance.

THE VIPR PROCESS



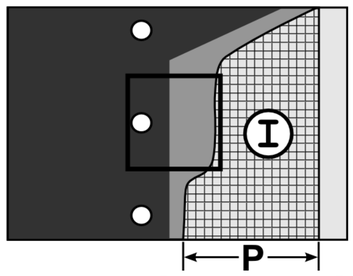
- The VIPR Process incorporates an external vacuum chamber into the standard VARTM process.
- A partial vacuum in the range of 1-5inHg of vacuum pressure is applied to the chamber which relaxes the fiber stack making the fabric more permeable.

VIPR GANTRY WORKSTATION



- The VIPR Process has been integrated into an automated workstation to control the deployment of the chamber during an infusion.

PI - CONTROL THEORY

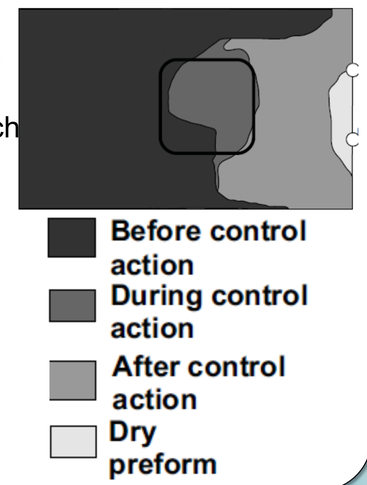


- PID style control theory is adapted for manipulating resin flow.
- At each time step simulations are conducted and minimization epsilon function shown above is used to determine the best deployment of the chamber.

$$\epsilon(t) = \frac{1}{L}\left[K_p \mathrm{P} + \frac{K_I}{n}\mathrm{I}\right]$$

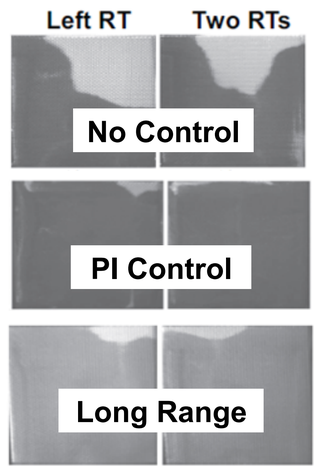
LONG RANGE FLOW CONTROL

- Long Range control studies simulation scenarios which represent the final stages of the infusion process.
- Here epsilon simply represents the amount of dry preform.



RACETRACKING RESULTS

- Results clearly show that using no control with the presence of racetracking is problematic.
- Further both PI and Long Range Control nearly eliminate these problems.



CONCLUSIONS/FUTURE WORK

- Using automated flow control drastically improves repeatability in VARTM processing.
- In the future many control theories will achieve ideal deployment for numerous flow scenarios.

ACKNOWLEDGEMENTS

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