THE EFFECTS OF TARGETED APPLIED VIBRATIONS TO PROMOTE VOID REDUCTION DURING COMPOSITES PROCESSING

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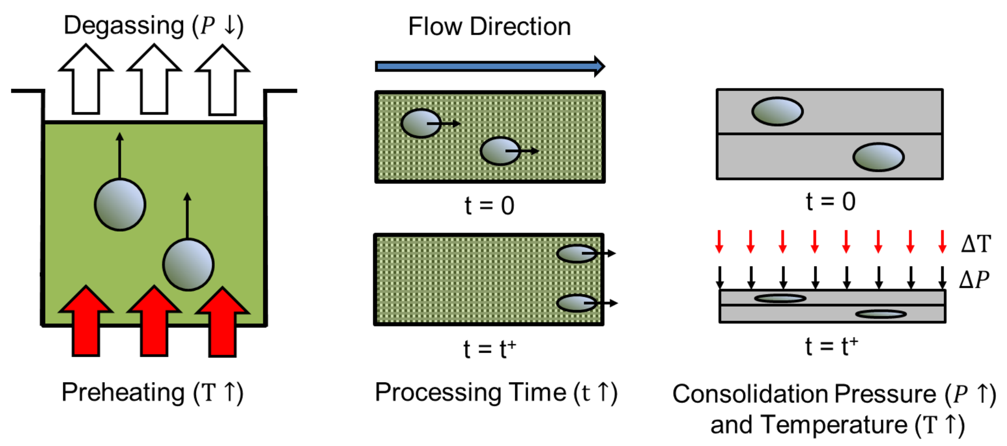
INTRODUCTION

- The elimination of composite defects such as voids is critical for high quality parts
- Voids are areas of high matrix porosity that result from trapped or formed volatile gases
- Voids can degrade the mechanical properties of composites
- Goal is to link void dynamics to process modeling and simulation for optimization

Typical methods for reducing voids:

1. Degassing or heating the resin prior to infusion (i.e. LCM)
2. Increasing processing time to allow voids to collapse or escape
3. Increasing consolidation pressure and temperature to compress the voids (i.e. OOA)



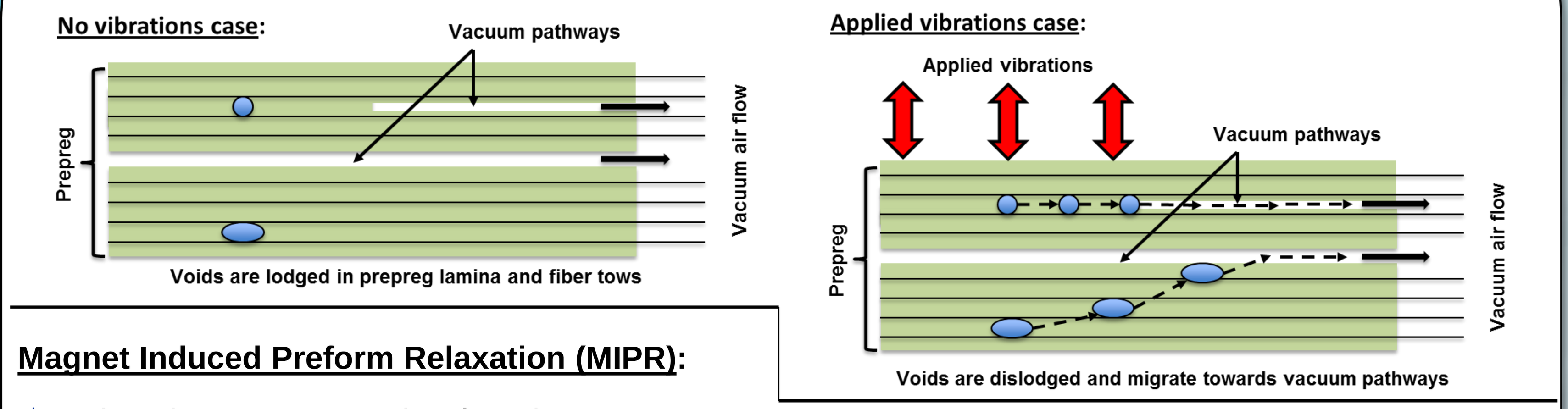
Issues with current methods:

Degassing	Preheating	Process timing
• Proper degassing time and pressure may not be known • Dependent on the resin volume and chemistry	• Infrastructure must be modified for elevated temperatures • Potential cost increases	• Need long process times for sufficient void removal • Slows down production

There exists a need for new ways to intelligently mitigate voids during composites manufacturing to drive down operating costs and improve production within the composites industry.

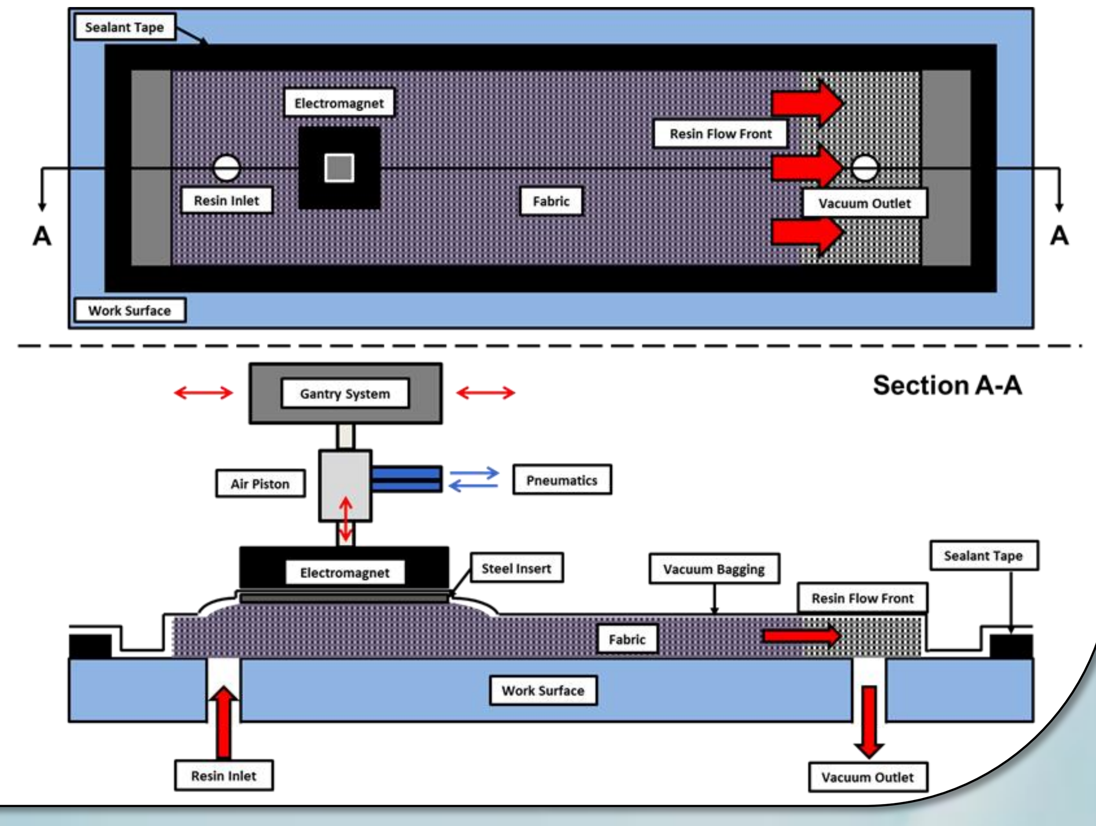
METHODOLOGY

- Use targeted vibrations to dislodge trapped voids and promote migration through vacuum pathways
  - Pathways within dry fiber areas act as "highways" in which voids travel to escape



Magnet Induced Preform Relaxation (MIPR):

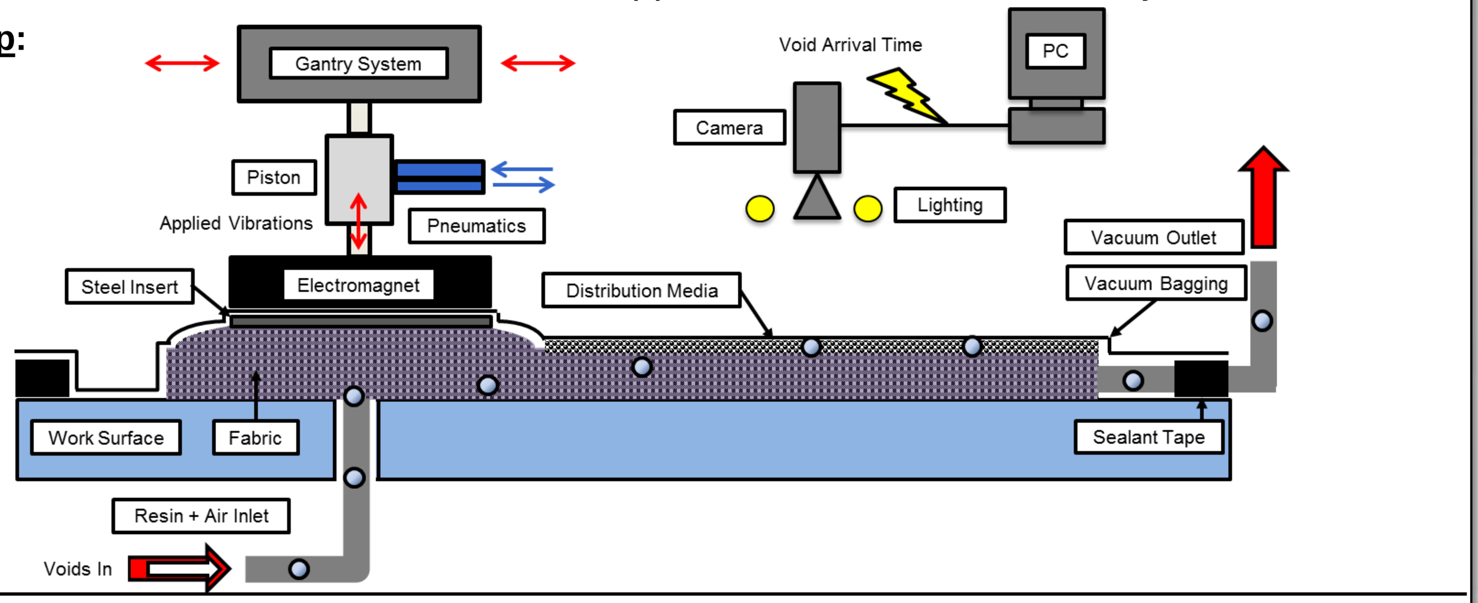
- Adapt the MIPR setup developed at UD-CCM for void control in OOA prepregs
- The MIPR setup uses a PC controlled gantry and flow visualization system to drive an electromagnet end effector
- A pneumatic piston connected to the electromagnet is used to pull up on a vacuum bag
- This relaxes the targeted area, thus increasing local fiber permeability
- This promotes local resin flow, which can dislodge trapped voids



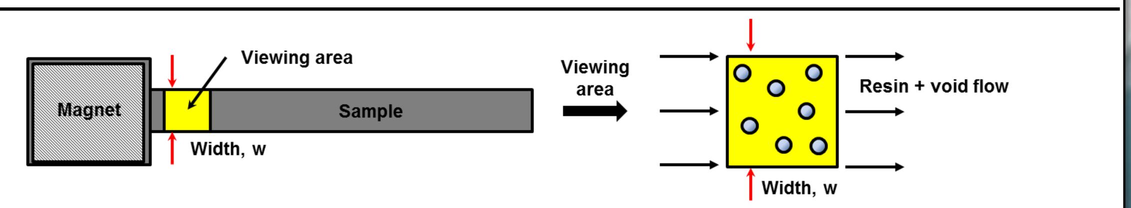
EXPERIMENTATION

- Preinfused resin in fibers before the introduction of voids simulates prepreg layups
- Distribution media (DM) models prepreg vacuum pathways
- Voids that are dislodged from the fabric can be recorded with CCD camera system
  - **Void arrival time**: the time voids appear in the DM after initial injection

Lab Setup:



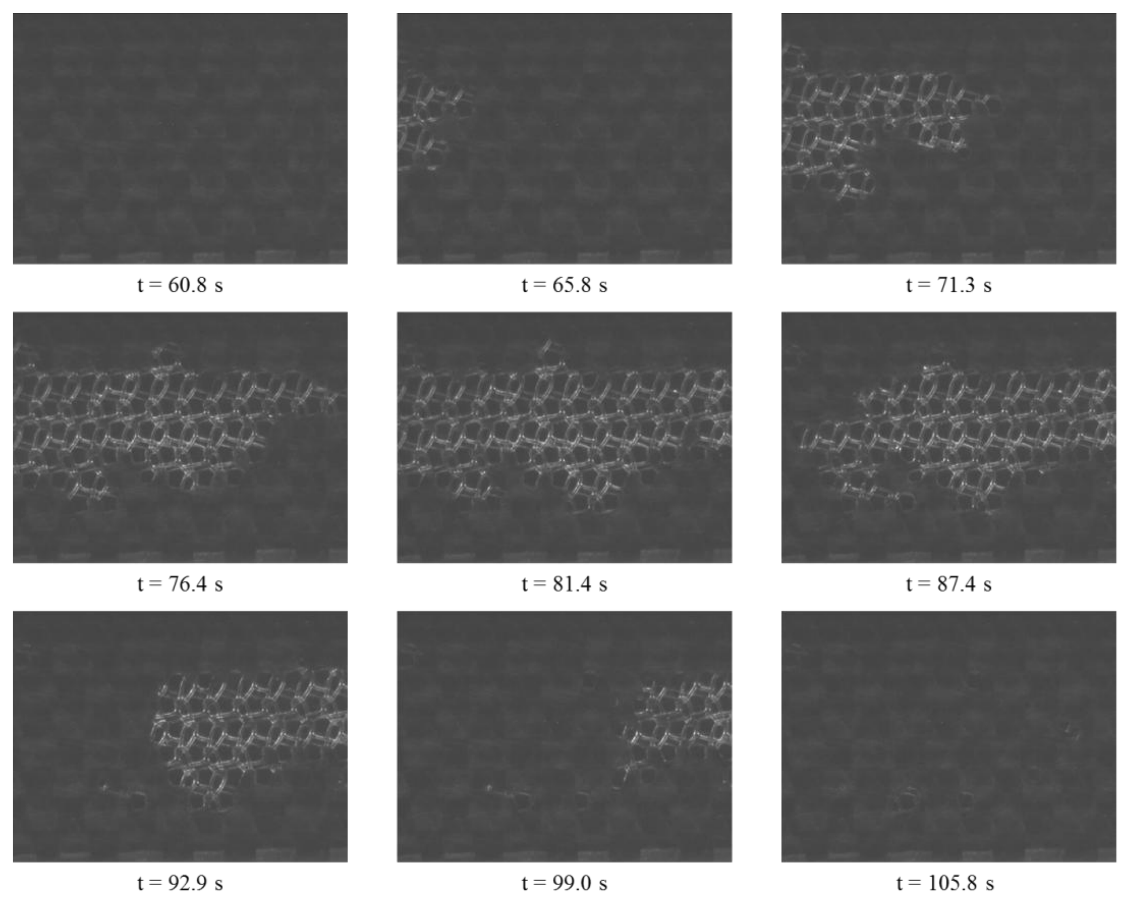
1D Sample Observation:



Experiment Flowchart:

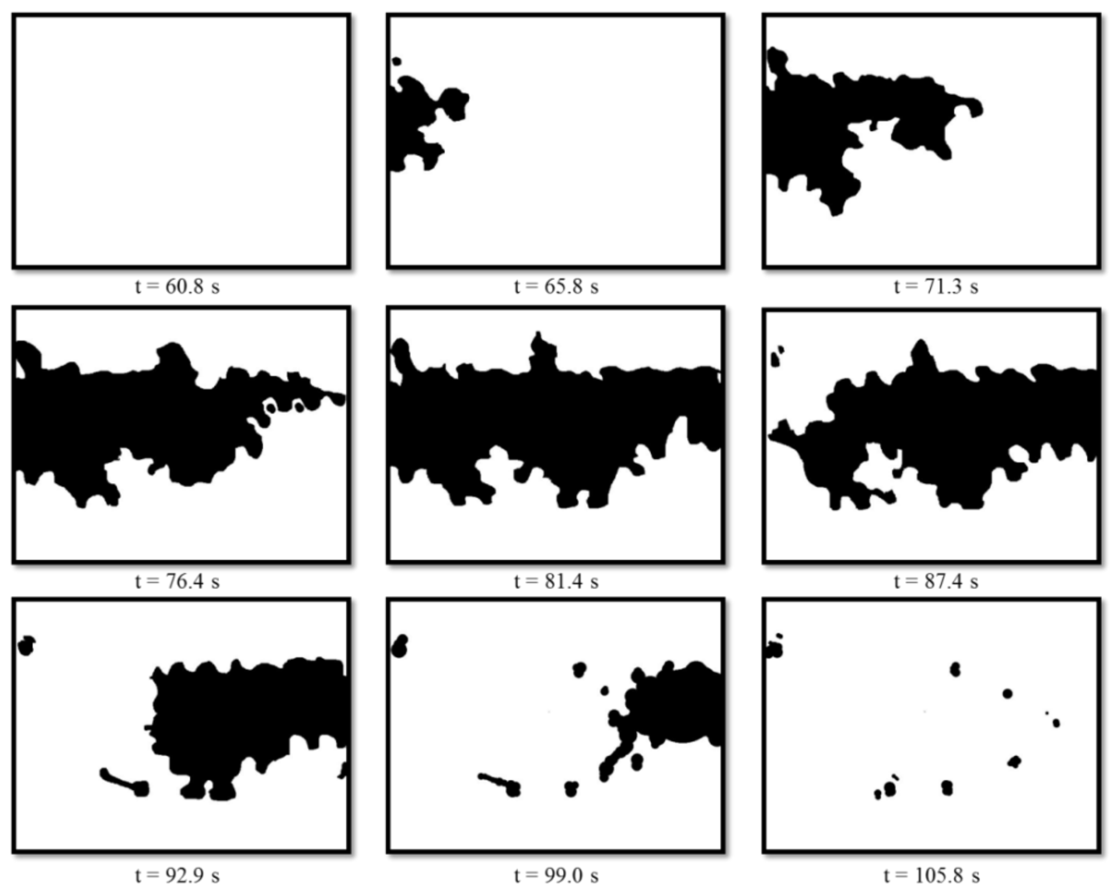
Place dry fabric layers and DM into VARTM setup with vacuum bag → Apply vacuum for resin flow continuously into and out of the vent → Introduce voids by removing the inlet tube for a specific amount of time → Monitor DM for void migration with camera system

FLOW VISUALIZATION



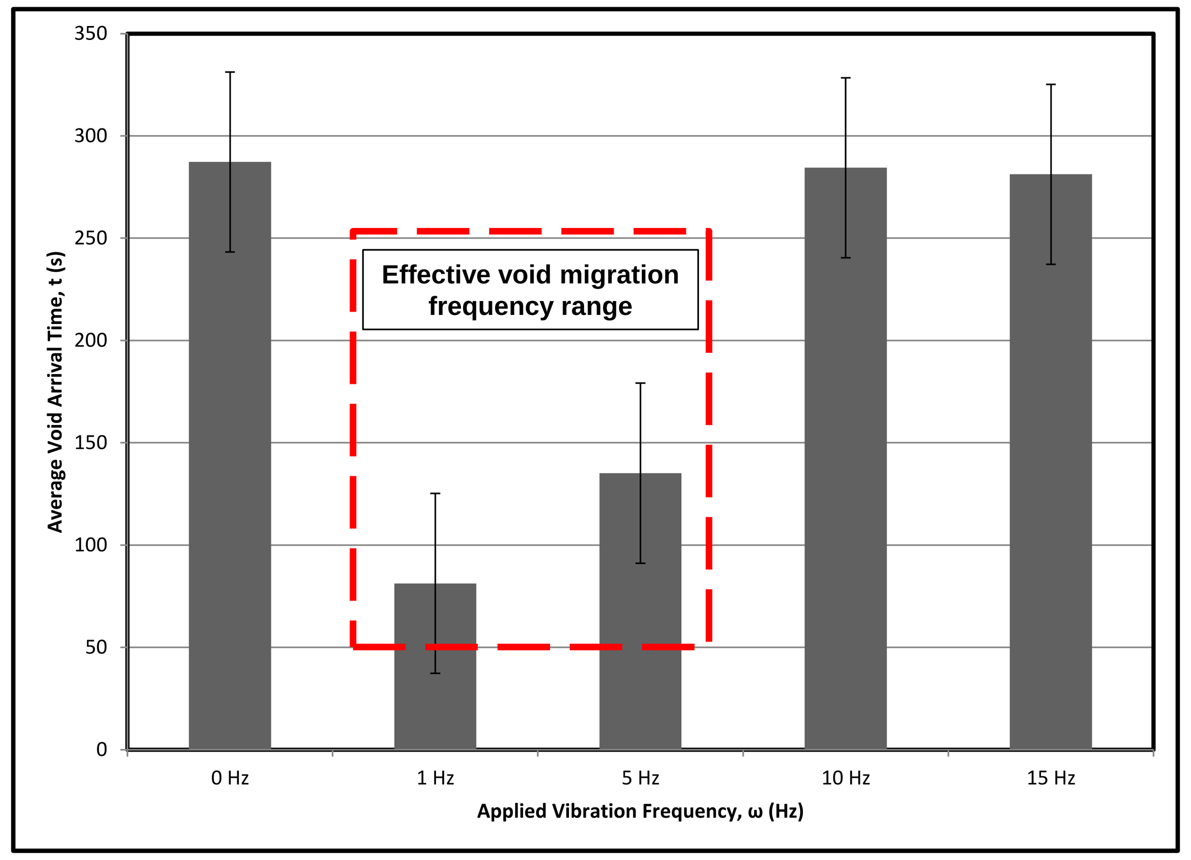
- The bright areas in the distribution media is the void migrating from the left to right towards the vacuum vent
- Viscosity of simulated resin (corn syrup + water mixture) is controlled

IMAGE PROCESSING



- Using our image processing capabilities we can also generate void area statistics of the images
- Void arrival time from the bottom of the preform into the distribution media was measured as a function of MIPR frequency

RESULTS



- Plotted is the average of five trials for each frequency along with standard deviation error bars
- The layup and resin batch were kept the same for every test at every frequency for experimental control

CONCLUSIONS

- From the model experiments, it was observed that MIPR changes the fabric permeability locally with each piston displacement cycle
  - The displacement cycling creates an effective pumping action
  - This acts as the primary driving force for the void dislodgement
- Results suggests that there is an optimal frequency range that promotes void migration
  - Lower frequencies (i.e. 1-5 Hz) were most effective
- Overall, the use of applied vibrations via MIPR remains a promising methodology for void mitigation during composites processing

ACKNOWLEDGEMENTS

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