

# TALL STRUCTURE INFUSION VIA VARTM

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## Objectives

- Develop fundamentals of tall structures infusion
  - Flow
  - Compaction
  - Size Limitations
- Approach
  - Develop experimental setup by building a composite mold:
    - As tall as possible (5m high, limit of manufacturing lab)
    - With an embedded sensor to determine the flow front
  - Develop simulation capability

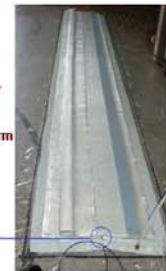
## Mold Manufacturing

### Mold set-up:

- 1 surface layer (7781 E-glass)
- 10 layers of E-glass
- 2 foams stiffeners (on all the length)
- 2 layers of E-glass to recover the stiffeners
- 2 wires sensor are embedded in the 1<sup>st</sup> layer of E-glass (TDR sensor: Time Domain Reflectometry sensor)
- Resin: Vinyl Ester

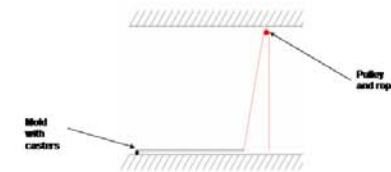
### Mold manufacturing:

- The floor is used as the tool
- A breather cloth is bagged and used as the mold for infusion
- A connector for the TDR sensor is fixed in the preform for permanent connection



## Experimental Set-Up

- The part is prepared horizontally on the mold and can be infused vertically



- The preform used for infusion is fixed:
  - 4 layers of E-glass 24 oz
  - Width: 8 inches
  - Length: 175 inches
- Before every injection the vacuum is checked by IPC (Intelligent Process Control)

## Experiments

- 6 different configurations are used:

### 1-> Baseline: Horizontal injection



### 2-> Bottom Injection

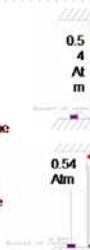
AP inside the pipe at 4.5m high

For water: 0.45 atm

For resin: 0.54 atm (density of resin: 1.2)

When flow front reaches the top of the mold, the pressure gradient is approximately 0.46 atm

3-> Top injection with low bucket  
When the flow starts at the top of the mold, the pressure gradient is approximately 0.46 atm



## Experiments

### 4-> Top Injection with high bucket



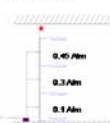
At the end of the injection, the pressure gradient is greater than 1 atm



### 5-> Multi injection: 3 injection lines surrounded by 4 vacuum lines



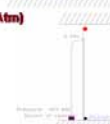
Optimization of the setup: reduction of the distance between the gales and the vents: 75cm (30 inches)



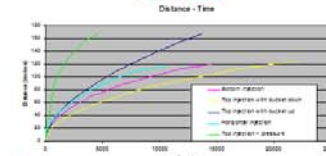
### 6-> Top Injection with low bucket + pressure (0.5 Atm)



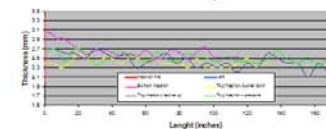
When the flow reaches the top of the mold, the pressure gradient is approximately 0 atm.



## Results



- The slowest process is when the resin has to be pumped up first, due to the pressure head loss on the top
- The fastest process is when the resin bucket is pressurized.



- The part obtained with the bottom injection is thicker (20%) at the beginning of the plate because the resin accumulates at the bottom of the mold and it escapes from the bag.

## Conclusions and Future Work

- The pressure due to the gravity is the most important factor in the infusion of tall structures and it influences:
  - The speed of the injection
  - The thickness of the part
- The future work will focus on:
  - The multi-injection of tall structures
  - Controlling the pressure value during the injection
  - Developing simulation and prediction tools

## Acknowledgements

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