

## CONCEPTS

### MOTIVATION

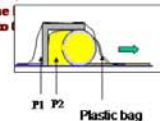
- ◆ Improve controllability
- ◆ Improve part quality, reduce resin waste, and decrease injection for VARTM
- ◆ Requirements of a control system:
  - ◆ Flexible
  - ◆ Simple
  - ◆ Low cost
  - ◆ Value
  - ◆ Reusable
- ◆ Previous work
  - ◆ Controlling VARTM flow
  - ◆ Real-time modification of resin viscosity via heating
    - ◆ Problems of materials parameters modifications
  - ◆ Potential changes to flow distribution confounded by premature curing.

### GOAL

Prototype and test hardware for VARTM Resin Flow Control

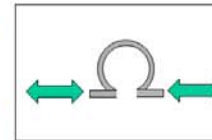
### 1. PNEUMATIC VALVE

- ◆ CONTROL THE RESIN FLOW
- ◆ Pressure Phenomenon
  - if  $P_1 < P_2, v = 0$
  - if  $P_1 > P_2, v \neq 0$
- ◆ Method of Operation
  1.  $P_1 > P_2$ : the bag moves and exposes the holes of the tube
  2. The resin goes in the area between the tube and the Plexiglass
  3. The resin is injected in the part
  4.  $P_2 > P_1$ : the bag closes the and the flow is reduced to 0



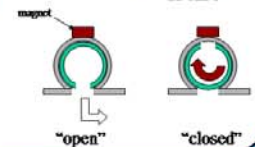
### 2. MECHANICAL SYSTEM

- ◆ Block channel in  $\Omega$ -tube
  - ◆ We can use hydraulic pressure to close or open the channel in the bottom of the  $\Omega$ -tube
  - ◆ When the channel is closed, the flow stops and when the channel is opened, the resin can be injected in the part
- ◆ Drawbacks
  - ◆ Cost of the system
  - ◆ We can not be sure that the channel is perfectly closed, so it's possible to have some leakage
  - ◆ Not reusable



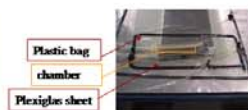
### 3. ELECTRO-MAGNETS

- ◆ Principle
  1. We have two tubes ( $\Omega$ -tube, circular tube with holes)
  2. The electric current is positive and the magnet attracts the circular tube
  3. The resin is injected in the part
  4. We change the current to negative, so the inner tube is pushed back
  5. The holes of the tubes are in the top
  6. The flow is stopped
- ◆ Problems
  - ◆ Resin leak
  - ◆ Rotation of the inner tube
  - ◆ Interactions between the different injection lines
  - ◆ Not reusable



### PROOF OF CONCEPT

- ◆ ADVANTAGES
  - ◆ Low cost
    - ◆ Plexiglass
    - ◆ Vacuum system
  - ◆ Simple
  - ◆ Reusable
  - ◆ Versatile



Three independent injection lines

### VALIDATION

#### FLOW CONTROL EXPERIMENTS



- ◆ Checking the viability of the concept
  - ◆ We conducted some tests to see if we can control the flow front during the injection
  - ◆ Tests confirm that we can control the flow

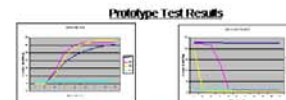
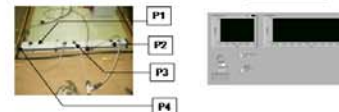
Race-tracking simulations

#### PRESSURE MEASUREMENTS

The results show that the vacuum is the same in the various chambers. The opening delay of the valve is 0.5 s, and the closing delay is around 0.1 to 0.2s.



Labview program used for Pressure Measurements



All 3 valve chambers opened. Only 2 chambers closed, one remains open.

### CONCLUSIONS

- The flow can be successfully controlled by a segmented injection line with pneumatically operated valves
- Possible Improvements
  - Eliminate the leaks of pressure
  - Address problems with the plastic when we close the holes
  - Eliminate vacuum supply variations
  - Improve repeatability



### FUTURE WORK

- Modify valve chamber/bag design to eliminate valve leakage.
- Simplify chamber design to reduce installation time and possible vacuum leaks.
- Use simulations to optimize the configuration of the valve chamber length.

### ACKNOWLEDGEMENTS

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