# ELEVATED-TEMPERATURE VARTM

**P. Schulze, T. Seyhan (Intern), C. Baudron (Intern) and D. Heider**

University of Delaware . Center for Composite Materials

## OBJECTIVES

### ♦Goals

- ✧Modify VARTM process for use with aerospace resin systems
- ✧Enhance process repeatability w/automation and control

### ♦Challenge

- ✧Toughened epoxy systems need elevated processing/infusion temperatures

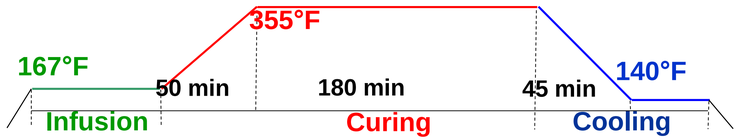
### ♦Objectives

- ✧Develop VARTM cell w/sensors and actuators to monitor and control process variables
- ✧Establish simple and safe resin processing
- ✧Evaluate benefits and disadvantages of VARTM modifications

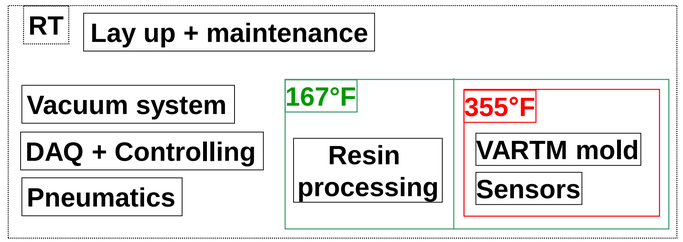
## SYSTEM SETUP MARCH 2006

### ♦Cycom 977-20 (Cytec Industries, Inc.)

- ✧Single-component epoxy resin
- ✧Representative of epoxy systems w/heat-initiated cure (highly exothermic!)




### ♦3 separate temperature regions

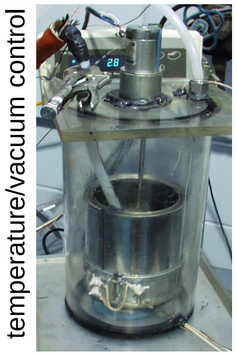



## MODIFICATIONS/ADDITIONS

### ♦Resin processing with vacuum connection

- ✧Degassing and heating are integrated in one chamber
- ✧Control of vacuum level allows “CAPRI” infusion (Controlled Atmospheric Pressure Resin Infusion)
- ✧Manual resin handling is limited to one step
- ✧Placement on scale allows flow rate measurement

Heating chamber w/ temperature/vacuum control



CAPRI specific debulking module for pre-compaction

## TEST PANEL FABRICATION

### ♦Manufacturing of test-worthy panels in VARTM modifications (SCRIMP, VAP, CAPRI)

- ✧Resin: Cycom 977-20 or Hexcel RTM6
- ✧Fabric: IM7 plain weave SGP-193-p CF
- ✧Lay-up: $[(0°)/(45°)/(0°)/(45°)]_{2S}$ ; quasi-isotropic, symmetric, balanced laminate

### ♦Fabrication with minimized variation in process parameters will allow objective evaluation of process ability and quality

## MECHANICAL TESTING

### ♦Intended mechanical testing procedures:

- ✧ASTM D-2344 Short Beam Shear
- ✧ASTM D-5766 Open Hole Tension
- ✧ASTM D-5961 Pin Bearing
- ✧ASTM D-6484 Open Hole Compression
- ✧ASTM D-6742 Filled Hole Tension
- ✧ASTM D-6742-02 Filled Hole Comp.
- ✧ASTM D-7136 Drop Weight Impact
- ✧ASTM D-7137 Compression After Impact

- ✧All tests in dry and hot/wet conditions

## ONGOING/FUTURE TASKS

### ♦Full CAPRI module integration, “Controlled” VAP capability

### ♦Fabrication of test panels in different configurations

### ♦Mechanical testing, SEM fiber volume/void content investigation

### ♦Comparison of VARTM processes, evaluation of benefits and development of database

### ♦Design, simulation and evaluation of complex part infusions

## ACKNOWLEDGEMENTS

**This work is supported by the Office of Naval Research through the Advanced Materials Intelligent Processing Center.**

**This project is also supported by the Federal Aviation Administration through the FAA Center of Excellence.**