Infusion Experiments of Versalink Polyurea Thermosets Resin System (VPS) using RTM Process/Mechanical Properties

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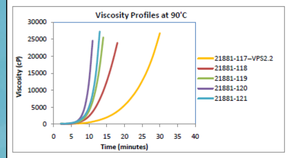
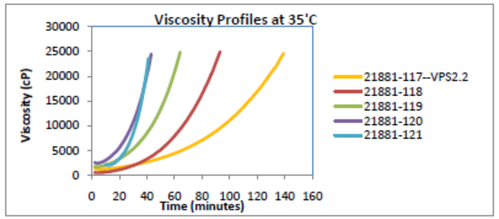
INTRODUCTION

- Develop a system of impregnating fibers with a very high initial viscose resin with short processing time
- Compare the VARTM Process for Standard low viscosity epoxy and vinyl-ester based resin systems with VPSII resin.
  - ✧Update infusion design tool to allow flow time prediction for high viscosity resin systems
  - ✧Develop a Standard Operating Procedures (SOP) for VARTM infusion of Air Products Versalink Polyurea resins in order to enable fabrication of low void content composite components.
- Develop an alternative Process (RTM)

PROBLEM DESCRIPTION

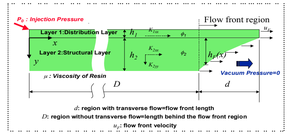
- Initial Resin Viscosity is ~2500cp
  - ✧The viscosity profile of the VPS is much higher compared to standard VARTM infusible resin systems
- Between 10 min to 1 hr working time
- Resin is very sensitive to moisture

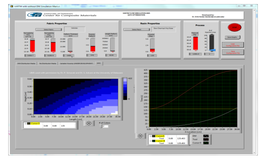




FLOW TIME ANALYTICAL DESIGN TOOL

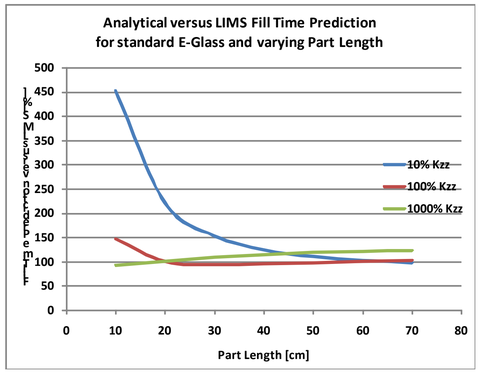
- A simple design tool to evaluate the flow behavior of high-viscosity resin systems was developed
  - ✧Embed LIMS model in the design tool which can accurately predict infusion times for high viscosity resins, as well as thick and short laminates





- LIMS model cycle time is about 100ms and seamlessly embedded in design tool
  - ✧It shows actual through-thickness flow behavior
- Design tool can now be used to predict infusion times correctly for short, thick and low permeability components

FLOW TIME COMPARISON



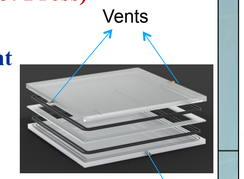
- Design tool can now be used to predict infusion times correctly

VARTM INFUSION PROCESS

- From the above tool, we were able to predict that two of the VPS resin (namely VPS2.2 and VPS22.1) with a gel time of 1 hour will impregnate 10 layers of S2 glass with a center infusion.
  - ✧ 2D and 3Tex fabrics been infused for property characterization with panels thickness ranging up to 0.7 inch and panels length up to 105 inches
  - ✧ Since the VPS resins are moisture sensitive, the fibers needed drying at 110°C for at least 2 hours under vacuum
  - ✧ The resins needed pre-treatment before mixing for moisture removal. The resin compose of Amine curative and Isocynate Resin. The Amine curative is preheat at 100°C under vacuum until no bubbles are observed and allowed to cool down to room temperature before mixing
- Fiber volume fraction in the range of around 54%.

RTM INFUSION PROCESS

- Five other VPS Resins have lower viscosity but faster gel time
  - ✧Resin Property requires higher injection pressures – Utilize RTM Process which may limit scaling-up compared to VARTM
- The Mold for the RTM Process is shown below
- The Process include (Using the hot Press)
  - ✧Vacuum is applied on both edges and ~50 tons of weight placed on the mold
  - ✧Leak check is conducted
  - ✧Part is heated to 35°C
  - ✧Resin prepared and infused at 80psi into the mold filled with the reinforcements
  - ✧Postcure and part demolded



RTM INFUSION PROCESS

- All the Panels have been fabricated with 10 layers of 24oz S2 glass $[0,90,0,90,0]_2$
- Some of these Panels have been tested for High Strain Rate Properties
- The remaining of these RTM panels are undergoing Testing for quasi-static properties including
  - ✧Combined Loading Compression (ASTM D6641),
  - ✧V-notch shear - In Plane (ASTM D5379),
  - ✧Drop-weight impact test (ASTM D7136) and Compressive Residual Strength (ASTM D7137), commonly referred to as Compression After Impact (CAI).
- 2 layer-Panels have also been fabricated for Tensile Properties for each of these resin
- Fiber Volume fraction of these panels range 56%-58% for the 10 layer panels and 60%-63% for the 2 layer panels