FORMING CELL FOR TUFF THERMOSET PART FABRICATION

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Introduction

- A **forming cell** is being developed for process development and manufacturing of small complex geometry composite parts to meet high volume requirements for the aerospace industry.

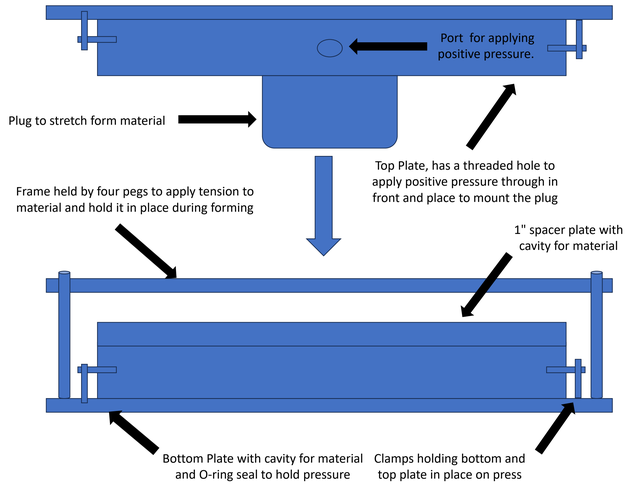


Figure 1: Forming cell description

- The forming cell uses highly-aligned short fiber thermoset prepreg (called **TuFF**) with its unique ability to stretch in-plane similar to sheet metal.
- The primary objective of this project is to validate the manufacturing process, find the ideal pressure and temperature, and prove system reliability.

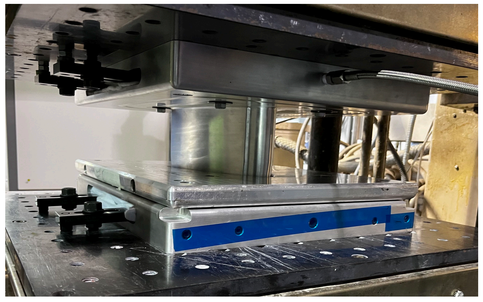


Figure 2: Forming cell setup without material holding frame

Manufacturing Process Verification

- A **triangular rib** has been selected as a model component to develop the forming process with an experimental plan to understand the interplay between process parameters.

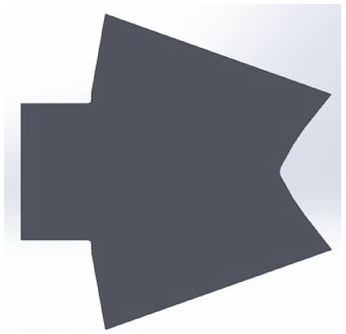


Figure 2: Triangular rib

- These Parameters include **temperature**, prepreg blank **boundary conditions**, forming **pressure and rate**, formed part **quality** (wrinkle-free formed geometry, good consolidation and cycle time.

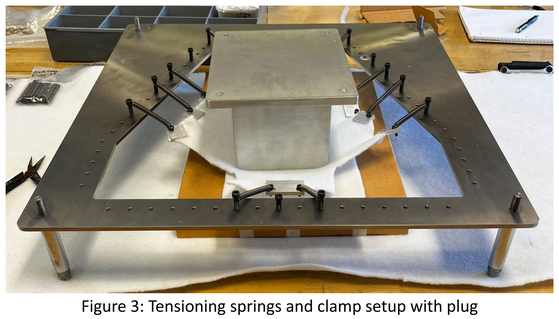


Figure 3: Tensioning springs and clamp setup with plug

- A custom metal frame is designed to hold the ‘material blank’ for triangular rib
- Metal clamps attached to springs are used to hold material in tension to facilitate forming
- Material Tension, clamping pressure and gripping mechanism are critical

Results and Discussion

Figure 4: Tension Test Setup

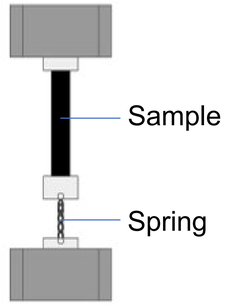


Figure 5: Tension test with spring setup

- Tension testing on coupons is conducted to determine the effects of critical process parameters including material tension, loading rate and temperature/pressure to help determine parameters for forming cell
- Aluminum tabs were used in the grips for testing

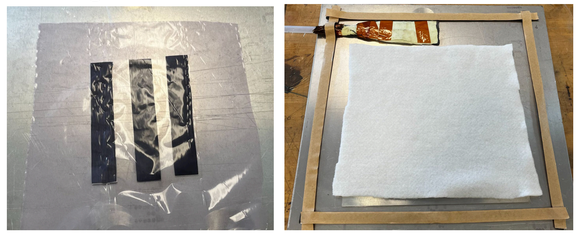
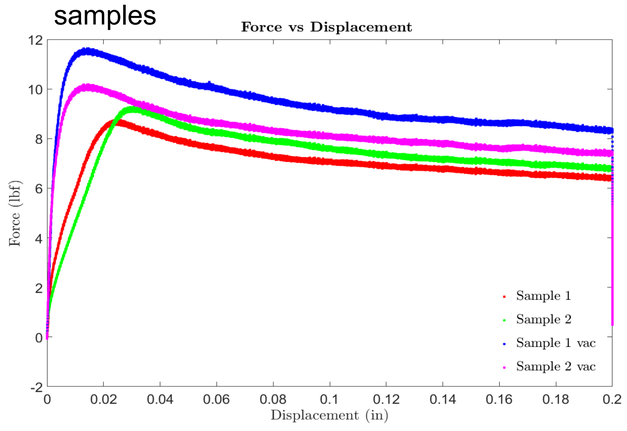


Figure 6: Material Debulking

- Debulking of material results in ‘homogenization’ of response and reduce variability
- Samples were debulked under vacuum prior to testing for comparison with non debulk samples



- **De-bulked samples**, which entailed a **15-minute** vacuum exposure prior to testing, exhibited an increased failure load in tension testing along with a higher stiffness response
- No slipping was observed in the samples during the tension tests, and no adhesion was necessary on tabs

Conclusions and Future Work

- Material stretch starts with loads in excess of 10 lbf/ply based on load-displacement data
- Debulking the material results in higher tension loads, and can help reduce variability
- Tests with varying loading rates to access material response
- Repeat testing with added springs to check any variation in response
- Failure mechanisms and blank gripping mechanism
- Preliminary trials are in progress to understand material stretch behavior as a function of force, temperature and rate, followed by blank forming trials to understand the influence of boundary conditions on stretch forming.

Acknowledgements

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