Composite Repair Housing Apparatus

INTRODUCTION

The aviation industry has seen a shift towards the usage of composite materials due to their strength, corrosion resistance, and fatigue properties. However, repairing small defects in these composite parts requires large specialized systems.

PROBLEM STATEMENT

The objective is to design, fabricate, and test a sectional housing apparatus capable of withstanding and measuring at least 100 psi over a 13”x2” area at 350°F for at least an hour. The housing utilizes expanding foam to put pressure on and cure carbon fiber coupons for local repairs.

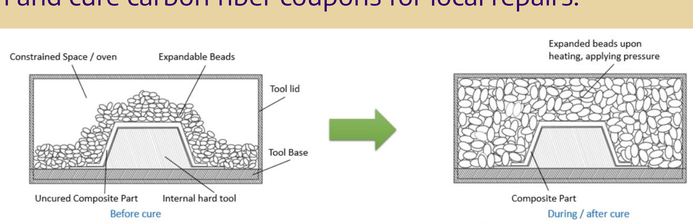

Figure 1. Foam expanding around carbon fiber coupon.

COMPONENT SELECTION

- Enclosure: 7075 Aluminum
- Insulation: 304 Stainless Steel
- Load Measurement System: Load Cell
- Heating Element: Hot Press
- Pressure Sensing: Pressure Film
- Mechanical Test: Instron 3-pt Test
- Control Coupon Cure Method: Autoclave, Hot Press

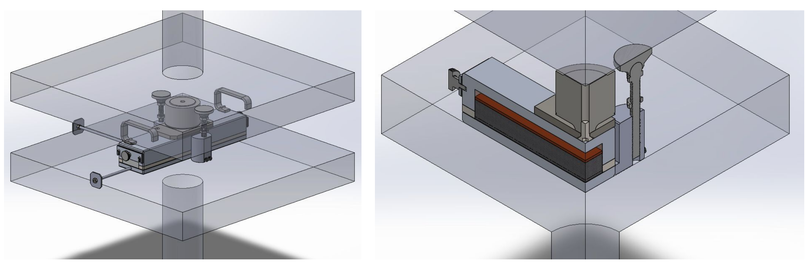

Figure 2. CAD model of the repair apparatus.

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DESIGN & DEVELOPMENT

- Enclosure
  - Parameters of interest: Measuring pressure & temperature
  - Conditions: Load cell cannot exceed 200 °F & 3000 lbs, design yield FoS > 3
  - Outcome: Design yield FoS > 4.7, integrated insulative layers and water cooling system for load cell

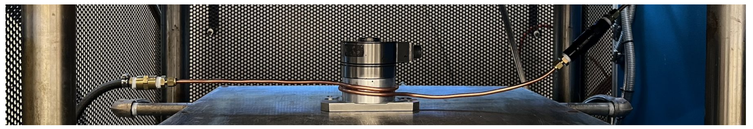

Figure 3. Copper tubing cooling system for load cell.

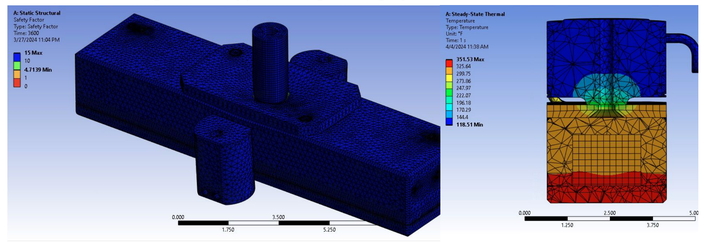

Figure 4. Structural and thermal FEA.

- Foam
  - Recipe: 71.4 wt.% Pacer technology red silicone, 14.3 wt.% Expancel 920 wet powder, 14.3 wt.% silver thermal paste.

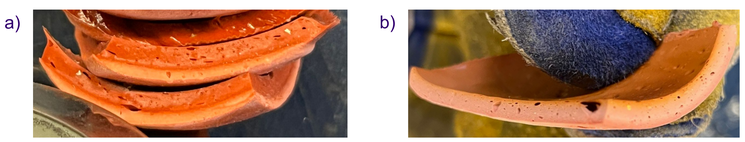

Figure 5. a) Foam without thermal paste. b) With thermal paste.

- Carbon Fiber Coupons
  - Lay up: 22 plies [0/90] (11 pre-cured, 11 repair)
  - Cure cycle: 355 °C at 85 psi for 2 hours
  - Repair conditions: autoclave, hot press, enclosure

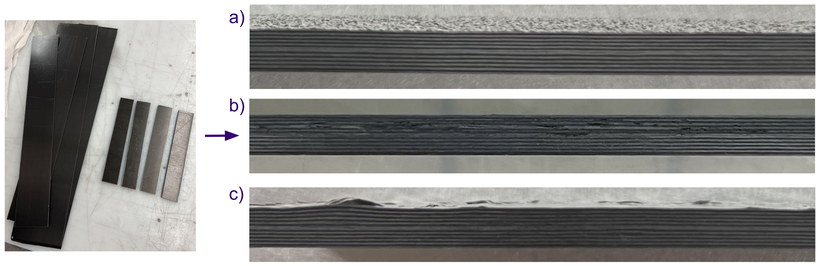

Figure 6. Carbon coupons cut with diamond saw (32:1 aspect ratio). Coupons repaired in a) autoclave b) hot press c) enclosure.

RESULTS & VALIDATION

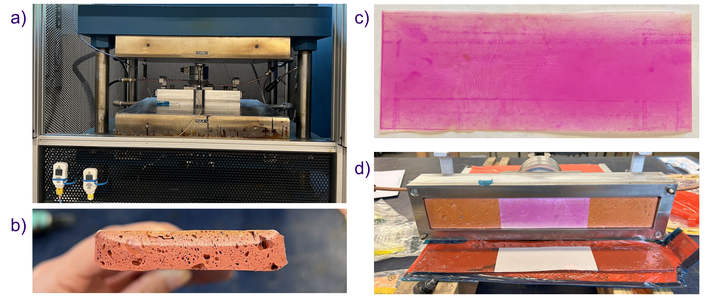

Figure 7. a) Enclosure in hot press with thermocouples and cooling system. b) Foam after expansion in housing. c) Fuji film indicating foam pressure exertion. d) Housing stack up post cure.

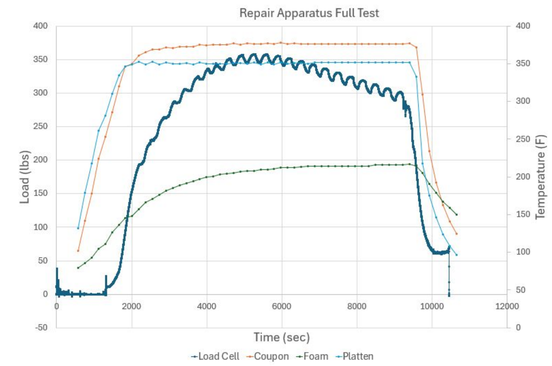

Figure 8. Full scale test of the enclosure while repairing a carbon coupon.

Results: The housing meets the required specifications. The max foam pressure exerted during repair was 15 psi.

- Cured at 350 °F for 2 hrs
- Set hot press clamp force at 8.1 % (~2,400 lbs)
- Thermal expansion of housing was ~1400 lbs

CONCLUSION & FUTURE WORK

- Thermal expansion in the housing prevented accurate measurement of foam pressure.
- Recommendations:
  - Further experimentation on foam characteristics
  - Iterate on design to reduce thermal expansion

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