PERFORATION MECHANICS OF DUPONT™ TENSYLON® 30A

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Introduction

- DuPont™ Tensylon® 30A is in large demand for research due to its impressive protective capabilities in the armed forces
- The structure of Tensylon® is a polyethylene film with a [0/90] sub-laminate architecture
- Tensylon® soft laminates of different thicknesses are created at UD-CCM and have been tested using a Quasi-Static Punch Shear Test (QS-PS)
- Compared to HB210, which is a polyethylene fiber with [0/90/0/90] sub-laminate architecture used for ballistic protection and is twice as thick per layer

Objectives

- Manufacture Tensylon® panels for testing
- Measure and determine the energy dissipating damage mechanics of Tensylon®
- Determine how well Tensylon® performs compared to HB210 in perforation testing

Manufacturing

- Soft laminates of layer counts 1L, 2L, and 4L have been manufactured in-house at UD-CCM via 150-ton hot press compression molding
- A custom frame of hardened steel is used which consists of four retaining walls, a bottom plate, and a top plate which create a 4.5×4.5×1in gap for composites
- One of the retaining walls has a hole for a thermocouple to monitor temperature

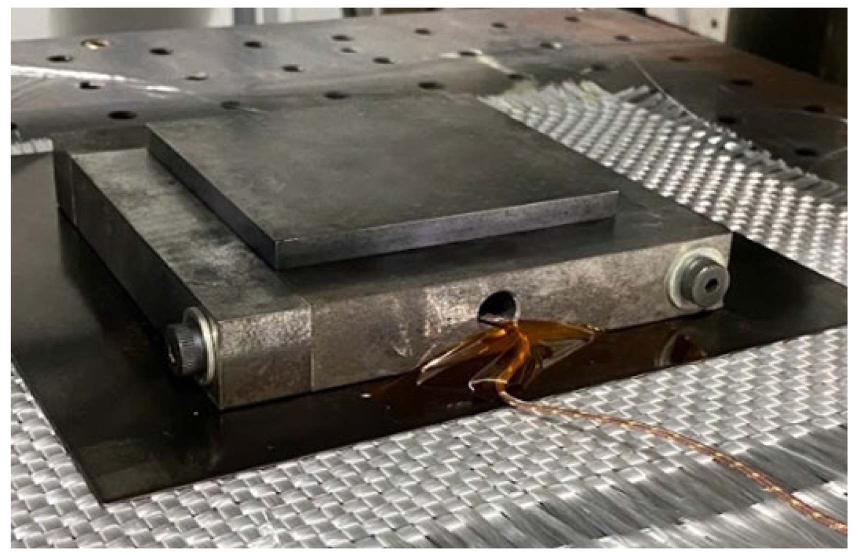

Figure 1: Custom frame for compression molding of soft laminates on a hot press with thermocouple.

- During the heating process, the desired number of sub-laminates are sandwiched between the top and bottom molding plates with high temperature film in between the various sub-laminates and plates to prevent undesired adhesion

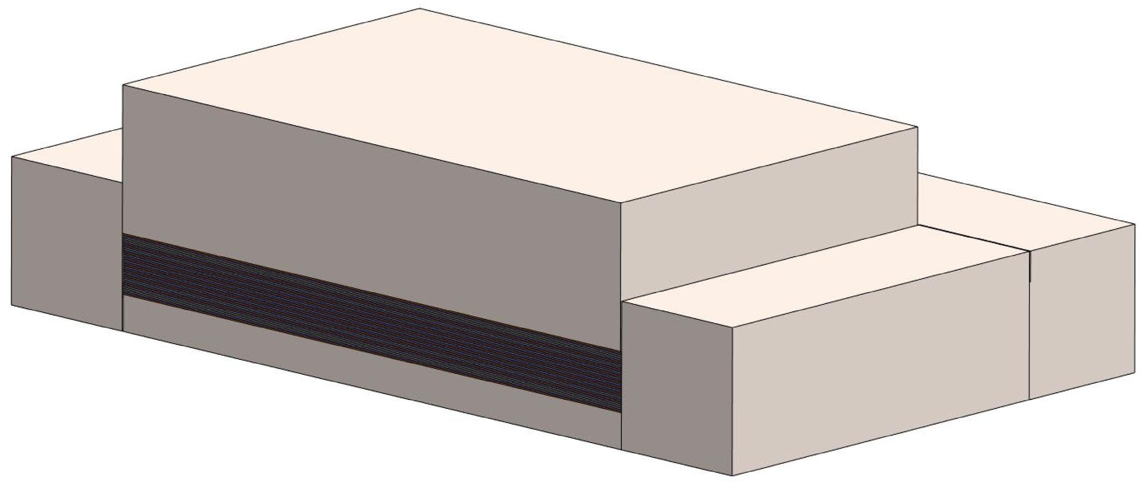

Figure 2: Soft-laminates were stacked in the order of (from the bottom) 4L, 2L, 1L, 1L, 1L, 1L, 2L, 4L with high temperature film in between each sub-laminate stack.

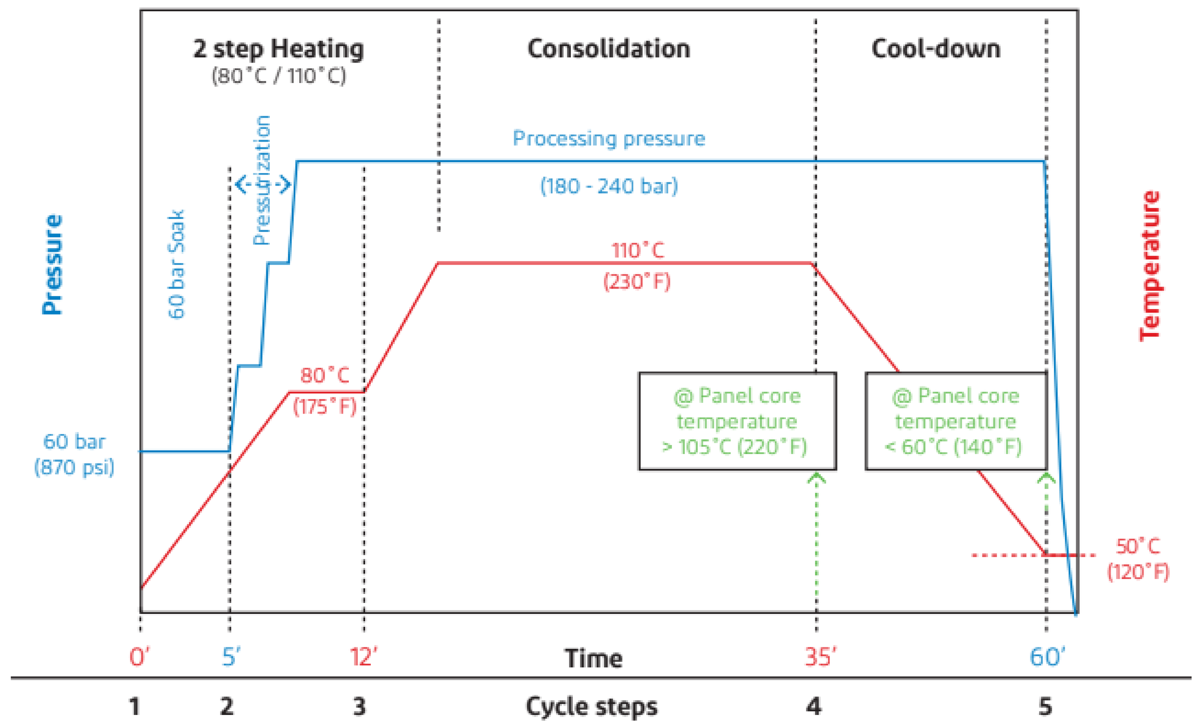

Figure 3: High pressure, two step heating cycle used for Tensylon® manufacturing. Careful balance between melting the material for resin application and avoiding damage is necessary.

Testing

- The 4.5×4.5in soft-laminates are cut into four separate 2×2in and 0.120mm thick pieces for testing to failure to progressive damage to plateau load level

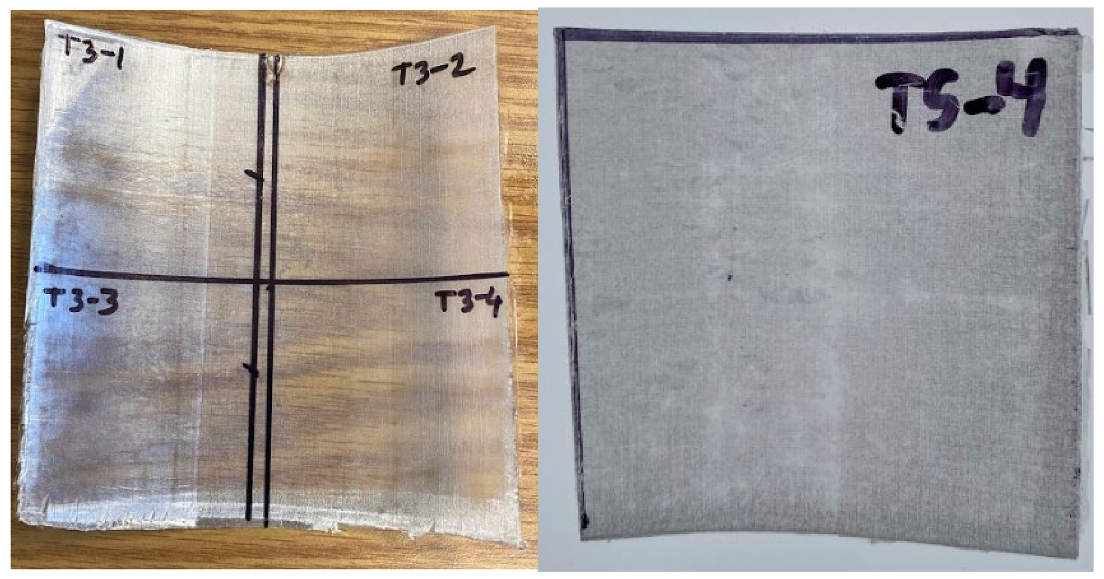

Figure 4: Single layer soft-laminate (left) and single cut sample (right).

- A QS-PS fixture consisting of a supporting plate, matching cover plate, punch guide, and 0.3in punch is used to press down on the soft-laminate until shear failure occurs
- Tests used annulus $a = (D_S - D_P/2)$ over thickness (H_C) of $a/H_C = 0.887$, support span (D_S) to punch (D_P) ratio of $SPR = 1.029$, and loading rate of $\dot{u}_z$ = 0.05 in/min

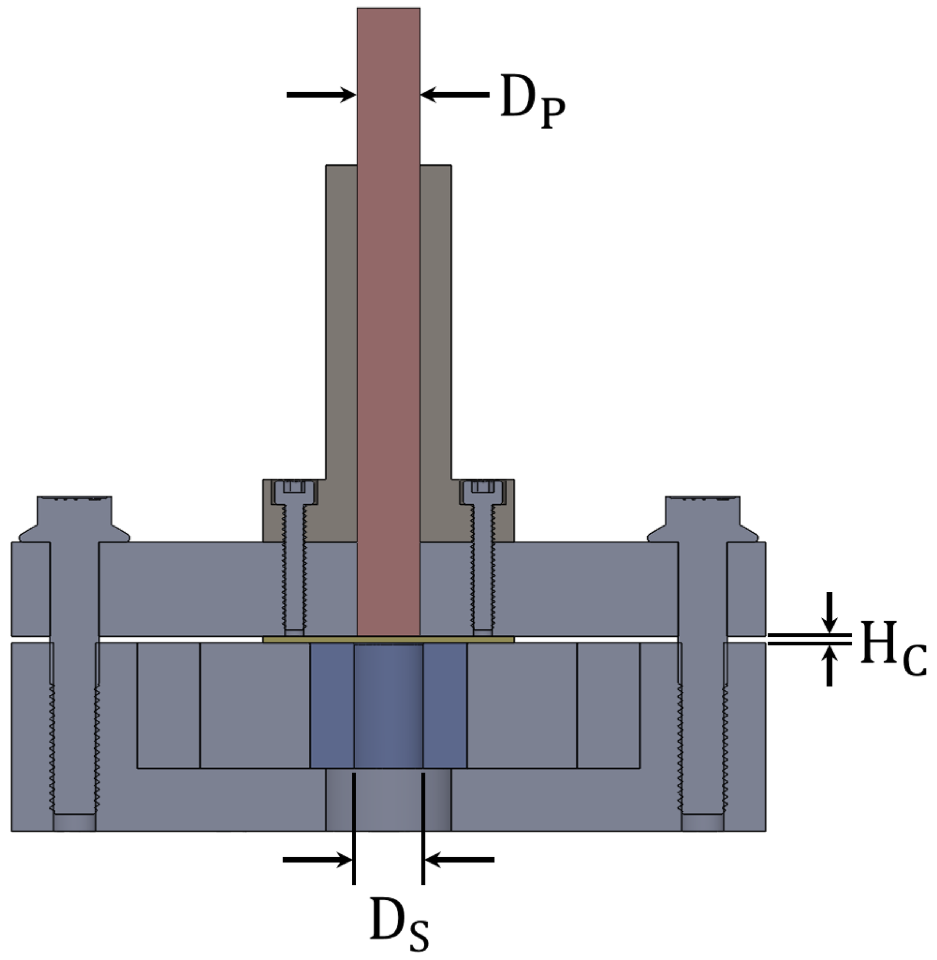

Figure 5: Quasistatic Punch Shear fixture for Tensylon® testing.

Results

- All average maximum loads experienced were equivalent at around 1.1 kN
- Average maximum load experienced HB210 of thickness 0.160mm were 2.0 kN while being 0.160mm thick and having a 4-stack sub-laminate structure
- The average maximum stress is 24 MPa
- The average work done on Tensylon® was 1.605 Joules

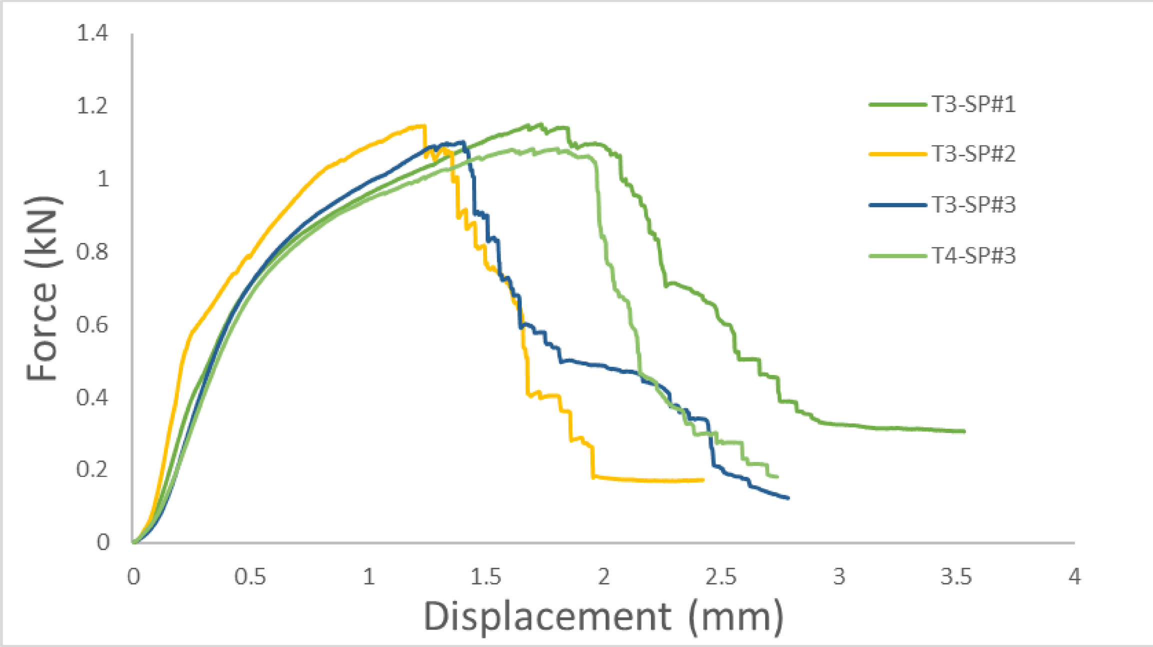

Figure 6: Load [kN] vs. Displacement [mm] of first four samples tested under punch-shear.

- The samples failed in shear with film displacement and tearing on the perimeter of the punch as well as material flow towards annulus region

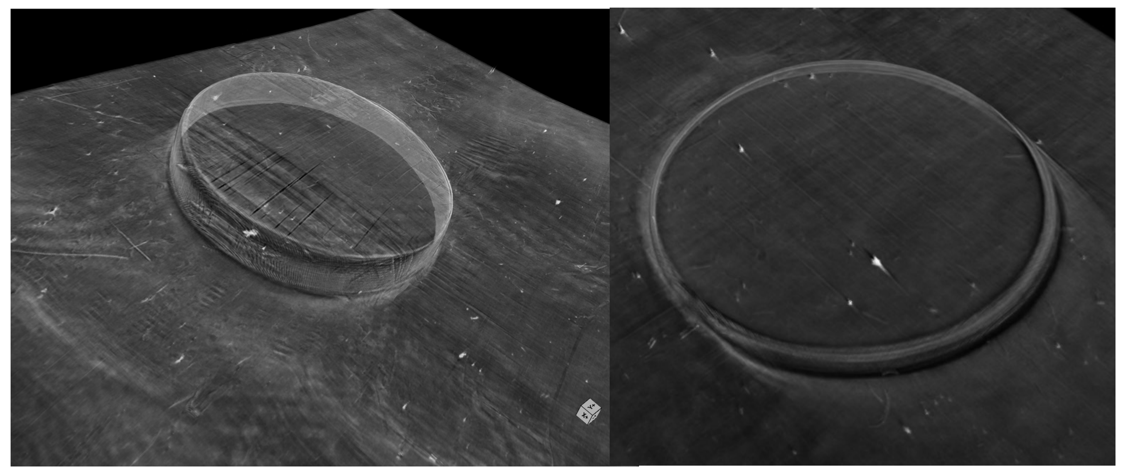

Figure 7: Underside CT images of fully loaded sample T4-SP#3 (left) and %50 partially loaded sample (right).

Acknowledgements

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