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Fabric Geometry Distortion During Composites Processing

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Waviness and tow misalignment are often cited as possible causes of data scatter and lower compression stiffness and strength in textile composites. Strength differences of as much as 40% have been seen in composites that appear to have the same basic material and structural properties -- i.e., yarn orientation, yarn size, interlacing geometry. Fabric geometry distortion has been suggested as a possible reason for this discrepancy, but little quantitative data or substantial evidence exists. The focus of this research is to contribute to the present understanding of the causes and effects of geometric distortion in textile composites.

The initial part of the study was an attempt to gather qualitative information on a **variety of textile structures**. Existing and new samples confirmed that *structures with a significant z-direction presence would be more susceptible to distortion* due to the compaction process. Thus, uniweaves (fiber vol frac: 54%-72%) and biaxial braids (vf: 34%-58%) demonstrated very little fabric geometry distortion. In stitched panels, only slight buckling of z-direction stitches was observed, primarily near the surface. In contrast, for structures with high compaction ratios -- e.g., large cylindrical yarns(2.5:1) or powder towpreg(4:1) -- *there were visible distortions where previously smooth and periodic undulations were transformed to abrupt changes in direction.*

A controlled study of the **effect of forming pressure** on distortion was conducted on type 162 glass plain weave fabrics. Panels (6x6in) were produced via a resin infusion type setup, but with an EPON 815 epoxy resin. Pressures ranging from hand layup to 200psi were used (vf : 34%-54%). Photomicrographs indicated that at pressures up to 50psi, large changes in thickness were due primarily to resin squeeze out. At higher pressures, when intimate contact was made between the layers, there was some tow flattening and in-plane shifting to optimize nesting. However, *even at 200psi the period and amplitude of the tow undulation remained constant,* suggesting that for this relatively fine fabric, distortions from compaction were not a problem.

Because of the interest in using larger tows (to reduce cost) and more complex structures, tests were also run on 2D triaxial glass braid (113 yd/lb @ 0, 225 yd/lb @ $\pm$ 45). Forming pressures of 20, 50, 200, and 500 psi were used, and **short block compression tests** were run. The 500psi specimen had a 10% decrease in modulus and an almost 50% decrease in strength (vs.20psi). Because the total fiber wgt/panel was kept constant, the thickness varied from 0.32 to 0.22in (49%-70% vf). Yet, the strength value is clearly below what would be expected, even with the decrease in thickness. Photomicrographs of these samples will be taken to determine if more fabric distortion exists in the 500psi specimens.

Finally, because the ultimate goal is to be able to predict and control distortion in a variety of textile structures, a **model compaction test** was developed to directly measure the deformation of the tows during compaction. Layers of dry glass fabric were placed in a mold with a clear plexiglass window. The yarn amplitude and period was then calculated using image analysis of the videotaped deformation. Preliminary tests demonstrated the feasibility of this technique for simple fabrics with large tows.

Further research is needed to isolate the transition from periodic (though not necessarily in-phase) nesting to the nonuniform crimp which may be the cause of localized differences in strain and net reductions in composite strength.