FORGED CARBON COMPOSITES

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MOTIVATION

Typical carbon composites are known for their high strength-to-weight ratio, strength in-plane, and overall stiffness. However, only thin surfaces and plates are easy to manufacture with carbon fiber, and more complex 3D shapes are difficult to create with carbon composites.

By contrast, forged carbon composites (FCC) are simpler to form into diverse 3D shapes. As a newer method, FCCs have limited material property data compared to metals/polymers, and we aim to examine the relationships of carbon tow volume through uniaxial tension tests of dogbones.

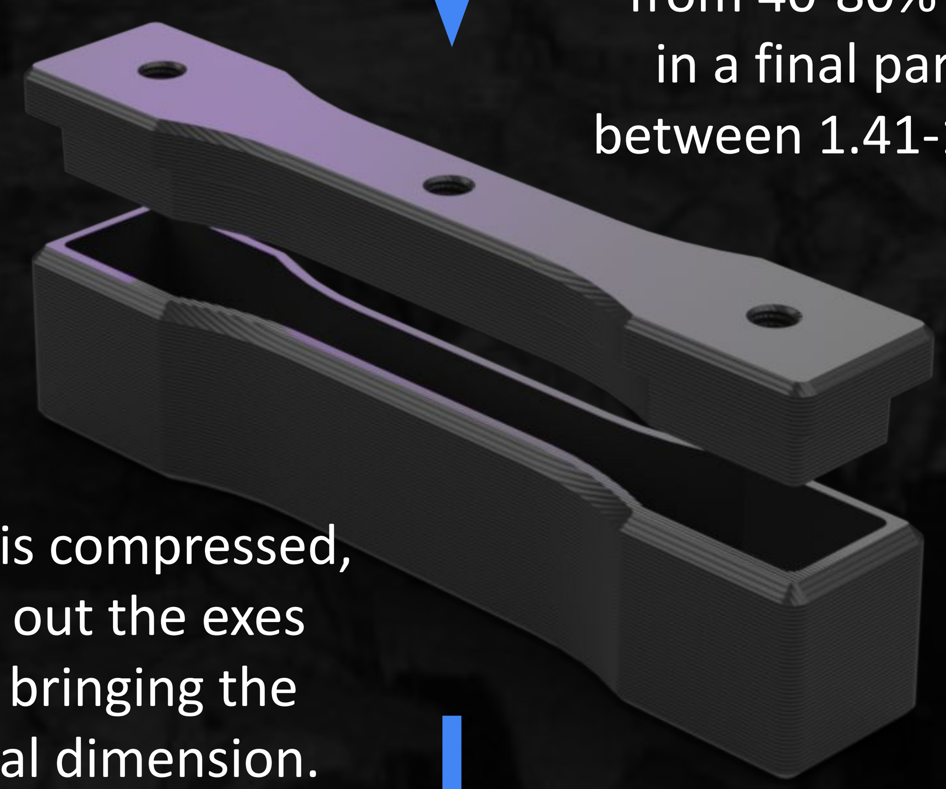
METHOD

Raw chopped carbon tow contains groups of fibers that are approximately 25mm long

The tow is made from polyacrylonitrile thermally decomposed to carbon fibers

Tow is packed into a two-part mold and mixed with epoxy resin

Each specimen contains a varying percent volume of fiber, ranging from 40-80% resulting in a final part density between 1.41-1.67 g/cc



The mold is compressed, squeezing out the exes resin, and bringing the part to final dimension. Ideally, every specimen will have an identical volume but unique density

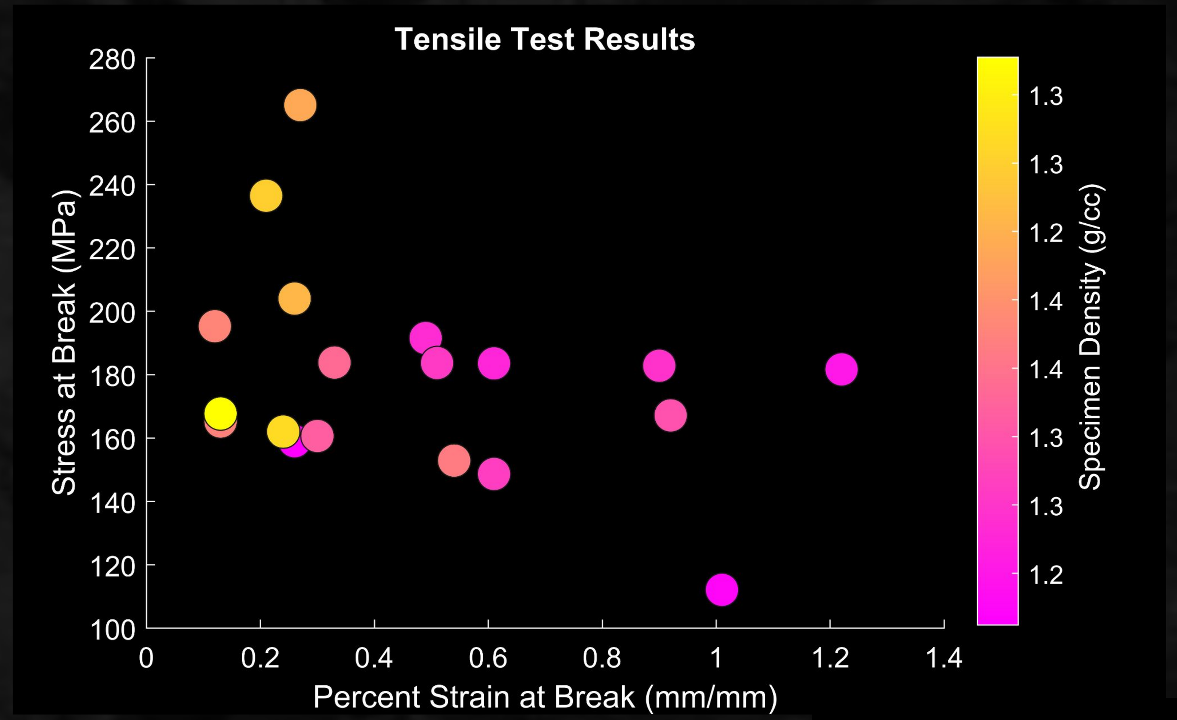
After 24 hours of curing, the specimens are ejected from the mold

Specimens are trimmed and sanded to remove mold defects

We made a total of 30 specimens across 9 factor levels

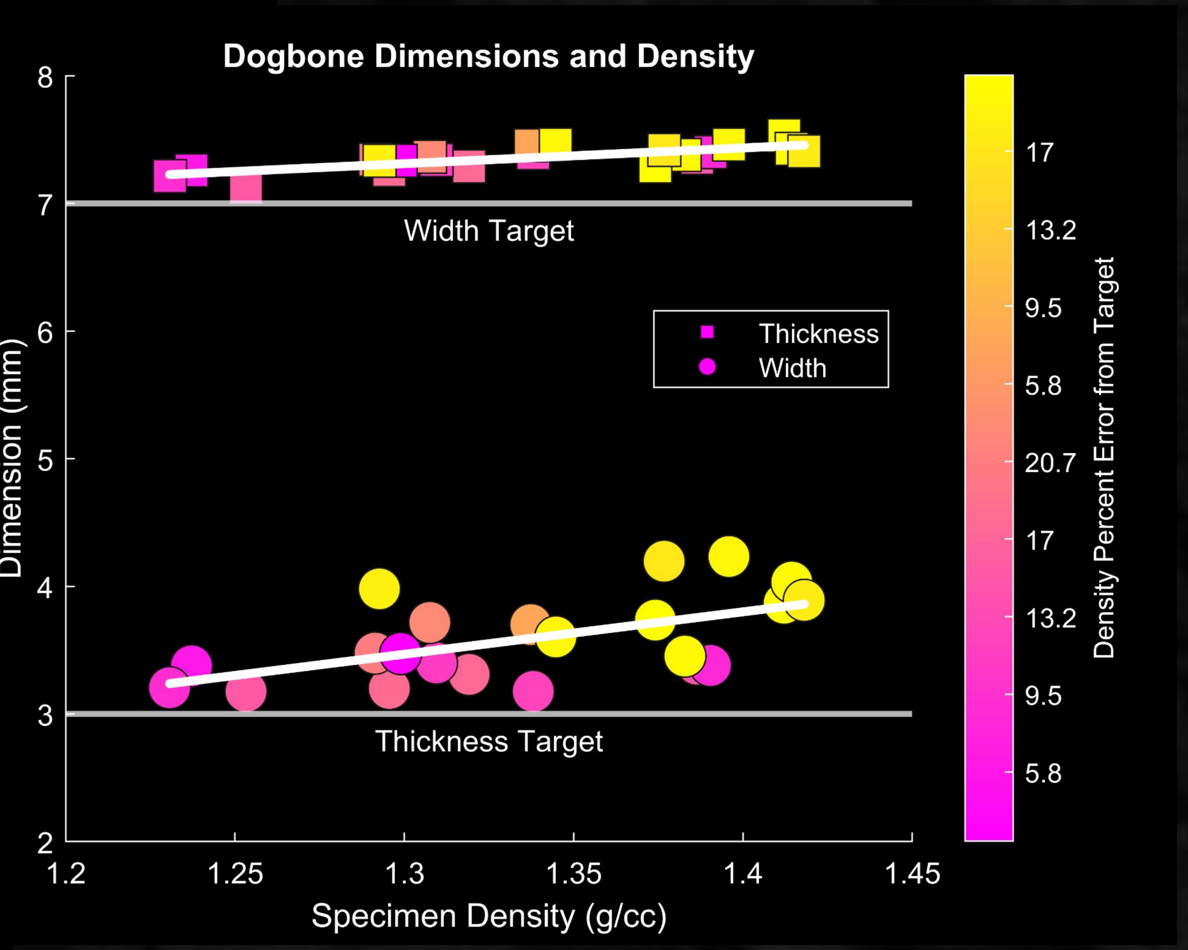
RESULTS

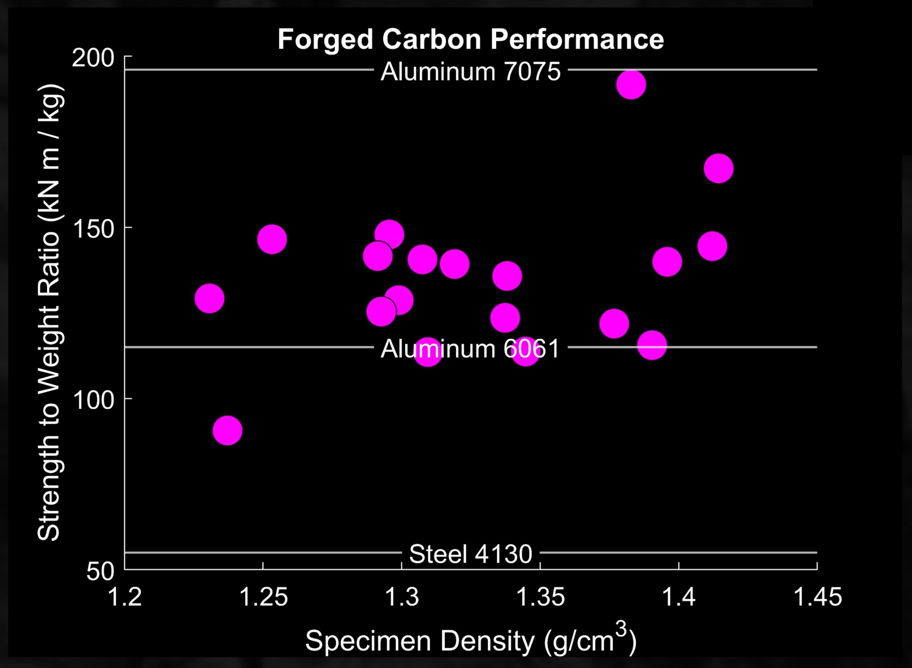
In this project, we demonstrated the manufacturability of FCC solid using simple materials and methods. In some cases, we found the tensile strength to be comparable to that of aluminum 6061 while weighing less. There were several factors that contributed to the uncertainty in our method and measurements.



This noise clouds any definitive correlation between carbon-resin ratio and tensile strength. Ultimately, this project shows why the predictability and consistency of metals make them more attractive for most enginerg purposes even if they are heavier and/or weaker.

Despite our efforts to control the density of the specimens, mixing the tow caused non-uniformity within and between the dogbones.
As a result, the tensile strength was highly variable and specimens would begin failing at a range of loads and strains both across and between factor levels.





Despite the poor data quality, the stronger specimens did tend to come from the samples with higher density (more carbon). The strength to weight ratios of the samples ranged from 90-190 kNm/kg.

Looking at the fracture-surface of one tensile test specimen, the fibers appear to have experienced tensile failure. This suggests that a significant portion of the load is being taken up by the carbon fibers which is the desired result. It also indicates good adhesion between the fiber and the resin since fibers are not pulling out of the matrix.