Why use Carbon Fiber composite filament?

Most people enjoy the semi-matte finish and chatoyant appearance that carbon composites can provide, yet there seems to be some confusion about the non-aesthetic reasons for or against 3D printing with carbon fiber composite materials.

Stiffness / Brittleness

- Stiffness = resistance to bending effort
- Brittleness = sharpening of fracture style at break event

Regardless of base filament material, any carbon fiber composite should be stiffer and therefore somewhat more brittle when compared with 100% base filament. Mixing carbon fibers into plastic creates a material that is typically greater than the sum of it's parts; the semi-flexible plastic material coats and sticks to the carbon fiber strands holding them together which helps prevent the strands fracturing under bending stress.

This phenomenon can be roughly demonstrated using straws: Holding 5 straws from a single end then bending them with another hand vs holding the same straws at both ends and trying the same bend in the middle. The straws being supported from both ends are much tougher to bend because they are being held together and able to better share their strength instead of each straw having to hold all the strain by itself.

Composite materials are a bit of a double edged sword because by adding a significantly stiffer strengthening material to our base plastic, we are adding nucleation sites for cracks to begin once the part is put under heavy stress. Unfortunately, these differences also cause a change in part failure "style"; this typically means a sharp violent break with reduced flexing when compared to the original material's properties.

The amount of *additional* stress a carbon fiber composite part will accept is usually *significant* compared to 100% base material parts, even if it does change how a part fails.

Printability

The increase to a base materials' overall stiffness will often reduce part warping significantly(or entirely) even for the more "warp prone" materials. This stiffness increase often enables getting

successful prints on challenging geometries, even when normal filament fails.

Hard Nozzle REQUIRED!

ANY composite filament will heavily increase the wear a 3D printer nozzle undergoes, so using a nozzle created from a wear resistant material makes great sense. The "Hardened Steel" nozzles tend to be the cheapest entry point, however their very low heat conductivity could require changes to the slicer temperatures in some cases. ANY of the hardened nozzle styles will allow regular composite use without problems, but there are always trade-offs.

- Hardened Steel
  - aka "Tool Steel"
- Obsidian
- Industrial Diamonds
- Ruby
- etc.

"Stainless Steel" nozzles are sometimes available, but I would not recommend them if they are not listed as "Hardened"; this is because while these WILL last longer than Brass, they will not even get close to the useful life of ANY "Hardened" (or equivalent) nozzle when used to print composites.

Glass Fiber? Aramid Fiber? Other Fibers?

- Carbon Fiber is not the only composite material, although currently it is the stiffest of the composites I am aware of.
- Glass fiber is typically half the "composite tax" ($ price > base material price) compared to carbon fiber with what I believe is 75% of the benefits and all the detriments of carbon fiber.
- Aramid Fiber and Kevlar fiber composites seem to stay similarly priced with Carbon Fiber but parts performed roughly identical to the Glass fiber materials in my testing.

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