Steel's last stand?

Advanced composites, whether they're in the latest fighter jet or high-dollar sports car, have long since proven superior in performance, especially given their relative weight, to traditional materials like steel.

But they've also been prohibitively expensive and difficult to process on a mass scale. Now, a new proprietary technology promises the mechanical and structural benefits of such composites with low scrap, reduced costs, customization, and cycle times of a minute or less, speeding past traditional hand layup processes faster than a composite-body stealth fighter.

The patented, tailored blank system from Fiberforge (Glenwood Springs, CO) is a continuous-fiber-reinforced laminate featuring multiple plies, which can be thermoformed into a net shape part in an automated process. The blank, itself, is a flat sheet created using proprietary software that roughly mimics the final part's shape in a 2D format. Built from a final part's CAD design, the blank helps minimize overall scrap, which is important given the cost of the composites used.

The program also allows for custom orientation of reinforcing fibers, placing them where they're needed. Fiberforge estimates that these tailored blanks can reduce overall scrap in composite thermoforming by 50% to 60%, while creating a material that is several times stronger and stiffer than steel on a weight basis.

The system is centered on a motion table with three movement capabilities—two linear and one rotational. Working in conjunction with the table is a layup head that feeds, heats, and places nonoverlapping strips of material on the table, building a series of plies at 1200 mm/sec. While the blank is fabricated, layer by layer, 3D features like holes and fiber orientation are incorporated.

Before they're formed, the sheets are consolidated in a heated, 408-tonne press. A consolidation mold with a two-piece silicone dam and two stainless steel caul plates is used. The consolidation temperatures for the PA 6 processed ranged from 220-260°C, while the pressures were from 3 to 10 MPa.

A recent study compared costs for producing spare wheel wells from several composites, with Fiberforge showing some benefits. Compared to existing composite sheet materials, carbon fiber/PA and carbon-and-glass fiber/PA hybrid blanks had improved cost effectiveness and weight savings of 50%. Scrap was reduced 50-75%, and the carbon fiber/PA blank had 20% lower cost, while the carbon/glass/PA hybrid had a 29% cost reduction. Also, compared to a traditional sheet molding compound, the tailored blanks offered a much higher volume of reinforcing material, as high as 55-65%.

These tailored blanks can be formed into net-shape parts via a variety of forming methods, including diaphragm forming, hydroforming, matched-die forming, and rubber-die molding. Fixtures are used for more complex parts, and once attached, the blank is sent to an infrared oven where sag will initiate entry into the thermoforming press. There, mold temperatures between 160-180°C are used with total dwell times of 45 to 90 seconds.

Pairing thermoplastics with advanced fibers and a proprietary software to create "tailored blanks," Fiberforge aims to replace the artisan craftwork of hand lay-up composites with a mass-production model, which brings the highly engineered materials to a broader array of markets.

Given that a primary potential market includes automotive components, Fiberforge has begun work studying possible surface treatments, with a class A finish as the eventual goal. In the study, a .075-mm PA 6 film was used alone or in conjunction with a $6.8 g/m^2$ carbon veil. By adding the veil, Fiberforge limited the fiber migration to the surface, improving appearance, but lessening the overall material strength.

This technology initially came out of a whole-vehicle design effort where the company investigated materials and manufacturing processes to develop lightweight, efficient vehicles, which would eventually feature composite components that could replace the automotive industry standard of a steel body-in-white. The company proposed a vehicle almost totally comprised of advanced composites that would reduce comparable vehicle weight by 57%, greatly increasing fuel economy while sacrificing nothing in terms of safety, performance, or aesthetic appeal. David Cramer and a team of engineers worked to promote and fine tune the tailored blanks, the most commercially viable technology that came out of their research. While a wholesale replacement of metal in cars is a ways off, the tailored-blank technology makes sense today.

"After talking with several automakers around the world and showing them the concept," Cramer says, "we got pretty much universal interest in how we were proposing to make the car's body."

Old materials, new process

Cramer stresses that Fiberforge doesn't represent a material advance. "Our carbon fiber is the same as anybody else's," Cramer says. "Our glass fiber is the same as anybody else's. It's just how we turn these materials into finished parts that we believe is more efficient."

Fiberforge is in ongoing discussions with several companies regarding licensing, and earlier this year it completed a concept seat project for Tier One automotive supplier Johnson Controls that used the composites to create a lighter seat with the composites partially exposed in a cantilevered hinge design that maximizes leg room.

Fuel costs are only one reason carmakers are looking to reduce vehicle weight, and Fiberforge is looking to cash in.

"The last major holdout for steel in cars is the body structure," Cramer says. "If you can reduce the weight of that structure by 50% or more, there is opportunity there if it can be done affordably."

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