



Structure, Sport and Style

New material advances with Forged Composite designs

By Angie McPherson

Recent manufacturing trends towards fuel-efficient cars, sustainable infrastructure solutions and renewable wind energy designs are forcing OEMs to look for reasonable alternatives to traditional metals. We know composite properties naturally provide these industries with lightweight and durable parts. However, the key to bringing more composites into these markets is to find more cost and time efficient solutions for manufacturing techniques. The University of Washington's Automobili Lamborghini Advanced Composite Structures Lab (ACSL) in Seattle, Wash., is working hard to develop such techniques. One of its biggest breakthroughs has been with Forged Composite, developed in collaboration with the Automobili Lamborghini and Callaway Golf.

Inaugurated in 2009, ACSL is a composite research center co-sponsored by airline giant Boeing and luxury sports car manufacturer Lamborghini. The center acts as a technology liaison for the two composite manufacturers and focuses on providing short-term research and collaboration on Lamborghini and Boeing projects as well as long-term research for composite innovation, focused on out-of-clave techniques. Forged technology

builds on advanced compression molding processes using short fibers instead of continuous strands to create a stronger material comparable to metal. This new process for manufacturing carbon fiber parts means

The Lamborghini Sesto Elemento carbon fiber concept car was developed at the Advanced Composites Structures Lab.

less time curing and less waste. As a result, it significantly reduces manufacturing costs and production time.

Cutting edge composite research

Forged Composite consolidates carbon fiber chips and a resin film into a sheet. The sheet is placed into a 1,000-ton heated matched metallic mold where the material cures in a short amount of time. The random arrangement of fibers creates a part stronger and lighter than aluminum. Once the part is cured it contains more than 500,000 fibers per square inch, which is similar to other carbon fiber reinforced plastic (CFRP) parts, but the Forged Composite part is manufactured in significantly less time. It is currently being used in the structural window frames on the Boeing 787, the head of Callaway Golf club drivers and the tub and suspension arms in the Lamborghini Sesto Elemento concept car.

Project #1: Boeing structural window frames



In 2005, Professor Paolo Feraboli, director at the ACSL, started working with Boeing and the Federal Aviation Administration (FAA) to test the new composite parts on the Boeing 787 Dreamliner. During this project, the ACSL tested several 787 components produced using Hexcel's HexMC, which is a new material derived from aerospace carbon fiber/



This is a sample of Forged Composite material.

epoxy tape. After determining that the short fibers would work well on the new Dreamliner, Boeing contracted with Nordam Interiors and Structures Division in Tulsa, Okla., to manufacture the structural window frames and other parts using a process similar to compression molding.

Nordam implemented the Hexcel HexMC-based parts in the window frames and other small parts like brackets, fittings and gussets that are typically made from aluminum. "The main difference between Forged Composite and the Boeing structural window frames is the materials used to manufacture. The parts developed by Forged Composite were short fibers combined with a resin film as opposed to the Boeing carbon fiber/epoxy tape that was chopped and assembled into a sheet," says Feraboli.

The change resulted in higher damage tolerant parts that are cheaper to construct than other carbon fiber methods and lighter than the usual aluminum parts. According to Boeing, the window frames are approximately 50 percent lighter than the aluminum counterpart. Nordam continues to manufacture thousands of structural window frames for the 787 and expects to yield more than \$200 million over the next 15 years.

Project #2: Callaway's RAZR Hawk



In 2007, the ACSL joined with the Callaway Golf Company, Carlsbad, Calif., in a collaborative effort to improve Callaway drivers with similar short fiber technology used during the Boeing structural window frames project. "We colloquially refer to the material as carbon fiber hardwood because it looks similar to cherry or walnut trees after manufacturing," says Feraboli.

Callaway wanted to collaborate to improve its bladder molded laminated construction on the Diablo Octane driver. "The laminated composites were limited in shaping and thickness variation and we were looking for a material that had more capability when it came to shaping," says Steve Ehlers, vice president of golf club innovation at Callaway Golf. Callaway uses Forged Composite to produce carbon fiber driver heads that meet the requirements for bending strength in the body and maintain low weight properties.

The RAZR Hawk driver, which was designed using the new technology, also takes advantage of the material's shaping properties in the head, shaping an intricate pattern that improves the aerodynamics of the club and includes shapes molded inside. This year's new adjustable driver, the RAZR Fit, which will be released at the end of January, uses Forged Composite in the head of an adaptable club that can change loft, face angle and weight distribution. Previously, implementing composites in this location would skew the driver's center of gravity. "After further research with the material, we determined how to use the weight savings and make an adjustable driver without sacrificing performance," says Ehlers.



The Lamborghini team building one of the 20 Sesto Elementos that will be released in 2013.

In recognition of its ingenuity, Callaway Golf was awarded the Award for Composites Excellence (ACE), Most Creative Application Award at the American Composites Manufacturers Association's COMPOSITES Show in 2011 for the use of Forged Composite in its RAZR Hawk driver. "We simply couldn't have completed that design with a laminated composite. Forged Composite proved to be a useful technology in our application."

Project #3: Lamborghini Sesto Elemento tub

The Lamborghini Sesto Elemento concept car, literally named the "Sixth Element" to represent carbon on the Periodic Table of Elements, was designed to be a test bed for carbon fiber technology. The Sesto Elemento used the research conducted at the ACSL and Callaway to complete carbon fiber testing in less than a year. The ACSL began working with the project in 2009 and the Sesto Elemento debuted at the 2010 Paris Auto Show in October.

The Sesto Elemento uses Forged Composite to lighten the car weight to approximately 2,200 pounds—which is 1,000 pounds lighter than the Lamborghini Gallardo Superleggera—and increase the power to weight ratio. The Sesto Elemento is powered by the same V10 engine as the Gallardo Superleggera, enabling the carbon fiber super car to accelerate from 0 to 62 mph in 2.5 seconds instead of 3.4 seconds. The car uses carbon fiber extensively throughout the vehicle, including Forged in the tub and suspension arms. Lamborghini replaced vacuum-assisted resin transfer (VARTM) molded parts to focus on testing Forged Composite technology and developing CFRP parts at higher production volumes.

"There were a couple of good surprises that came out of the Sesto Elemento's development. For example, we didn't realize a Forged tub would work as well as it did. The whole manufacturing process only took five minutes. That was a good confirmation that exceeded our hope and expectations," says Feraboli. According to Lamborghini, the same part would normally take a full day using VARTM, three to four days with a woven



The Sesto Elemento features a Forged Composite tub that cures in five minutes.

prepeg, and four to five days with a prepeg. The next step for further integration of this technology into other car designs is to develop a repair strategy for the carbon fiber parts. "As you can imagine, if a plane on the runway gets hit by a servicing truck, or if a car gets hit on the highway, the repair technician will need to know exactly what kind of damage has occurred. So we have developed a strategy with Boeing to conduct research on the repair process," says Feraboli.

At the 2011 Frankfurt Auto Show, Lamborghini announced it will produce 20 Sesto Elementos by 2013 solely for track use. The Sesto Elemento concept is an important technology development test bed and it will push the integration of composites into other Lamborghini family vehicles. Some of the carbon fiber parts developed during the Sesto Elemento trial are anticipated to filter down to other Lamborghini car designs such as the Volkswagen Group, Audi, Porsche and Bugatti, and it hopes to spread the use of the Forged Composite process to the rest of the automotive industry.

The future of Forged

All three manufacturers, Boeing, Callaway and Lamborghini, agree that the new technology is "the way of the future." Parts are made faster, stronger and structurally

less rigid. For example, after already seeing an impact in the sports industry, Callaway says it will continue to research Forged Composite integration and expects to use it extensively in new drivers.

Ehlers is also involved in helping the rest of the industry adapt to the new process into other sports equipment. "I've been talking to a number of companies on how best to use the material," says Ehlers. "Without naming specifics, expect to see this material in many other parts such as crank sets for bicycles and derailleur parts," he says.

On the automotive front, Feraboli expects that future Lamborghini designs will continue to see more power ratio increases through weight reduction from technology like Forged. "We need to continue to make production more amenable for other cars that are less expensive than the Sesto Elemento," he adds. The ACSL and Lamborghini are still developing new out-of-autoclave materials and processes for carbon fiber. "We're going to continue our research. It has been a goal of Lamborghini and the ACSL over the last few years to improve and implement carbon fiber technology," says Feraboli.

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