

CWE 2009 Preview

COMPOSITES TECHNOLOGY

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LOTUS ELISE
CONCEPT

ECO ENHANCED



Nanomodifying
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ECO Elise Concept

LEAN, SPEEDY & GREEN

Focus on use of sustainable materials and cleaner manufacturing processes promises future Lotus customers “almost-guilt-free” performance.

For auto OEMs, race cars and street-legal supercars have provided the “worst-case” testing laboratories in which some of the most valued safety and performance-enhancing features on today’s production passenger cars — airbags, seat belts, antilock brakes, fuel injection, rack-and-pinion steering, all-wheel drive, and bucket seats — were first evaluated. But apart from more efficient engines and lighter weight bodies, these test beds rarely yield environmentally friendly technologies. Lotus Cars (Hethel, Norfolk, U.K.) has taken steps to correct that deficiency with the *ECO Elise* concept car, a revamp of its popular rear-engine *Elise S* roadster.

Like its namesake, the *ECO Elise* features hand-layed composite body panels bolted to an extruded and bonded aluminum frame. It also uses the same powertrain. From the standpoint of tailpipe emissions, the *ECO Elise* isn’t as “green” as the plug-in electric *Tesla Roadster*, which Lotus Engineering designed and Lotus Cars builds for San Carlos, Calif.-based Tesla Motors.

Because Lotus already has among the most fuel-efficient cars on the road — its supercars get better mpg ratings than

many passenger cars — engineers took a different tack. “Having already worked extensively on powertrains,” says Group Lotus environmental manager Lee Preston, “we decided to focus on the environmental benefits of using sustainable materials. This is why the *ECO Elise* promotes a different perspective on ‘green’ — one not directly tied to tailpipe emissions, but rather looking at the materials in the building process.”

WHY BROWN IS THE NEW GREEN

The most visible difference between the *ECO Elise* and the *Elise S* is the brown accent stripe of hemp-reinforced composite that starts at the front bumper fascia/clamshell and sweeps up across the hood/bonnet, over the roof and the roll bar cover and then down across the spoiler. The exposed hemp fibers in the stripe — an eco-warrior’s equivalent to visible-weave carbon fiber — signals immediately that this car is different.

Lotus swapped out its typical fiberglass reinforcements for hemp in the composite body panels, the double-curvature fixed hardtop and the spoiler. Annually renewable, carbon-sequestering and affordable, industrial hemp (which is not psychoactive) has been used for millennia to produce products as diverse as rope, sails and apparel. Its properties — high-strength, toughness, durability — are among the best of today’s natural fibers, and the energy required for its conversion is low. The use of hemp in place of glass reduced the weight by 2 lb/1 kg per panel at the same nominal wall thickness because of the natural fiber’s lower specific gravity.

The hemp composite also forms the lightweight seats, each now 14.1 oz/400g lighter than its same-sized predecessor. (The *ECO Elise* also showcases ethical/eco-friendly materials in noncomposite applications. See “Toward a *Total Eco*-solution” on p. 48).

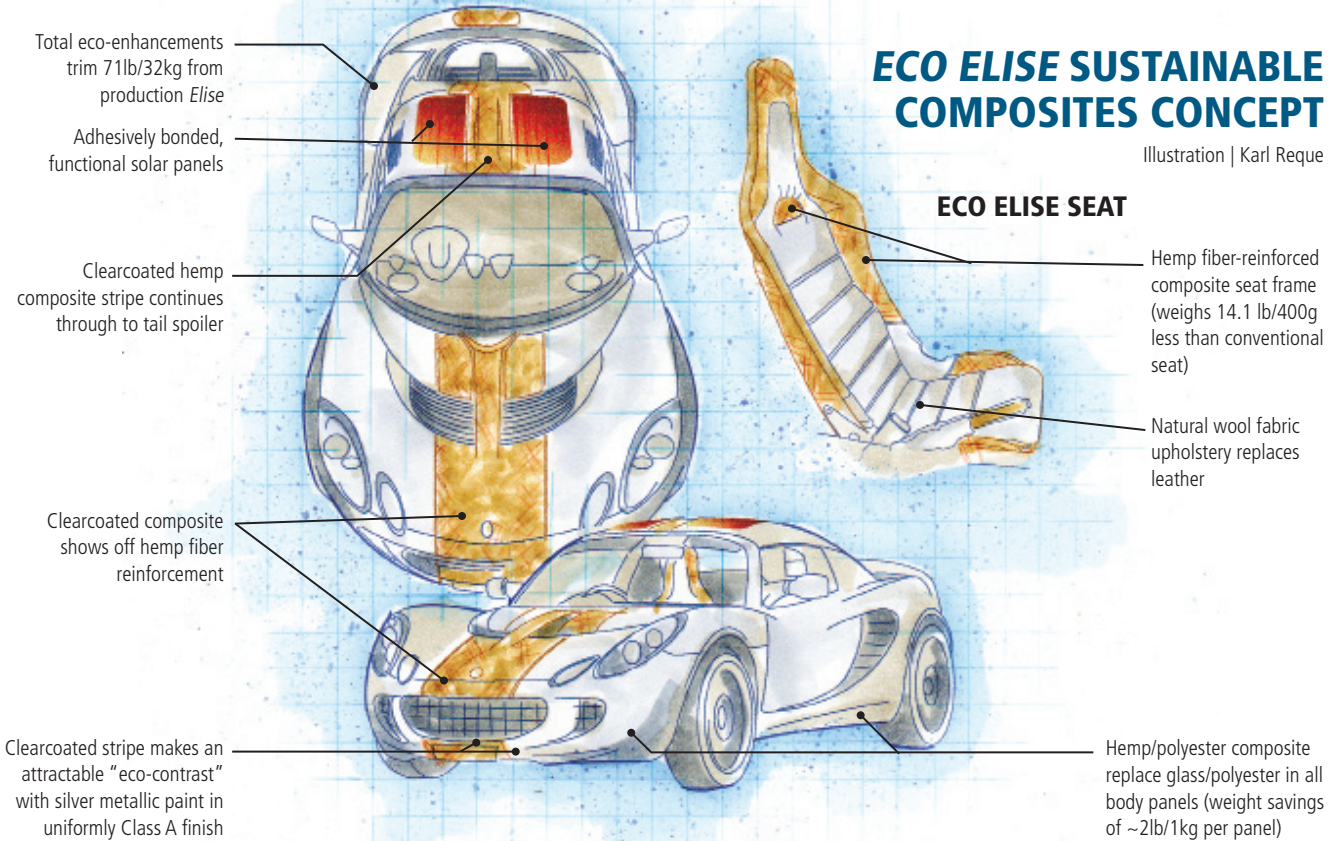
Although the matrix used in most of the hemp composites is the same unsaturated polyester used in Lotus production car bodies (supplied by Reichhold Inc., Research Triangle Park, N.C.), the company is reportedly seeking a recyclable (melt-reprocessable thermoplastic)



Based on Lotus Cars’ existing *Elise S* platform, the *ECO Elise* concept car sports hemp-fiber-reinforced polyester body panels in place of standard glass/polyester. Hemp fibers visible in the bold, unpainted bumper-to-spoiler stripe make a striking eco-contrast to the silver metallic finish.

ECO ELISE SUSTAINABLE COMPOSITES CONCEPT

Illustration | Karl Reque



ENGINEERING CHALLENGE:

Explore ways to reduce vehicle mass and mitigate the environmental impact of auto production and ownership through the use of sustainable materials and cleaner manufacturing processes.

DESIGN SOLUTION:

A concept car with composite body panels and seats that feature locally sourced hemp fiber reinforcements, plus functional roof-based solar panels and a completely water-based paint system.

alternative. Notably, the company says the same tooling and process steps used to mold standard fiberglass parts were used to produce the hemp composites. Most body panels were vacuum bagged/autoclave cured to achieve good consolidation and low weight, but more complex parts, such as seats and front access covers, were resin transfer molded (RTM) using matched metal tools in a hydraulic press.

Significantly, the hemp-composite seats were subjected to the same internal testing protocol used to validate conventional seats and passed with ease, demonstrating hemp's potential value as an automotive material. Although no crash testing has been done to date, the underlying crash structure, which manages the bulk of the energy, is identical to that used in the *Elise S*.

CLEANER, GREENER, LIGHTER

Beyond the body, Lotus looked at the overall environmental impact of vehicle production and ownership from two perspectives:

Process — creating cleaner manufacturing practices, using sustainable materials, increasing recycling, and reducing the carbon impact of logistics.

Performance — using renewable energy during production and in use, reducing vehicle mass to improve fuel economy, and promoting more fuel-efficient driving techniques.

“Fuel efficiency is probably the most important factor in greening the road,” Group Lotus CEO Mike Kimberley acknowledges, “but we mustn't forget how we are making these vehicles. With tens of millions of cars manufactured annually, production also has a huge impact on the environment. Mindful of this, we have taken a holistic approach by focusing on how it is made as well as how it performs.”

As Preston explains, “The new green materials we sourced for this car were carefully studied to ensure that each reduces the environmental impact of the vehicle.” For example, Hemcore Ltd. (Halesworth, U.K.) sourced the hemp from U.K. farmers in East Anglia, supplied it in bales of fibers, which were subsequently chopped at Lotus to lengths ranging from 0.3 inches to 2.2 inches (7 mm to 55 mm). Local sourcing reduced the carbon miles required to produce the vehicle. Additionally, component life cycles were analyzed — during production, in use and at end of vehicle life. “The technologies we used aim to lower both solvent and CO₂ emissions during vehicle life as well as to reduce energy consumption during manufacture,” says Preston.

Lotus was already carefully managing logistics between its manufacturing and paint facilities at its headquarters in Hethel and its other manufacturing site in nearby Norwich, which reduces energy consumption and emissions as parts are transported through the supply chain. Key suppliers use the company's Kanban-driven ▶



TOWARD A TOTAL ECO-SOLUTION



The seats, door panels, shifter boot, horn pad and other interior surfaces were upholstered with special undyed eco-wool. The carpet is woven from sisal fiber. ■

Source | Lotus Cars



The *ECO Elise* concept marks a significant milestone in Lotus Cars' comprehensive effort to ensure that its cars are as eco-responsible as current technology permits. Beyond composites, Lotus upholstered the seats (except for visible, clearcoated composite sections around the seat periphery) in durable, breathable

wool fabric rather than the leather Lotus typically uses. The EU Flower-certified wool was ethically produced and minimally processed, without dyes or other harmful processing. Its color is inherent to the special breed of sheep that produce the wool. The eco-wool also is used to skin door-trim panels, the steering-wheel horn pad, and the shifter and parking-brake boots and console covers. Natural beech wood (unstained but varnished) was used for the shifter knob and handbrake handle. Tough, abrasion-resistant sisal, a natural fiber that, like hemp, is fast-growing and carbon-sequestering, was woven into carpeting supplied by a local carpet retailer. Further, the car features a gear-change indicator with a green light (driven by Lotus-developed software) that coaches drivers when to shift to maximize engine fuel economy — as opposed to the common red lights on supercars by Lotus and others that tell drivers when to shift to maximize engine performance.

barcode system, and plants reuse durable and disposable packaging multiple times to reduce waste. However, further environmental impact studies led to changes at Lotus, during 2006 and 2007, that reduced consumption of electricity (14 percent), gas (30 percent) and water (11 percent). Moreover, 57 percent of waste from all Lotus operations now is recycled. Additionally, the company is erecting three wind turbines at its test track. When these come online (about 15 months from now), they will power the entire Hethel site, and energy generated in excess of the site's needs will be fed into the national grid to help power homes in nearby villages.

Lotus extended its eco-reach *beyond* its walls by incorporating two flexible solar panels from Flexcell UK, a division of VHF - Technologies SA (Yverdon-les-Bains, Switzerland), into the *ECO Elise's* hemp-reinforced hardtop. The panels are adhesively bonded to the roof, which features an optically clear epoxy matrix, also supplied by Reichhold, to protect the panels and prevent water ingress. Although the small roof area limits their size, panels are functional and contribute supplemental power to the car's electrical system.

Another significant eco-innovation used on the vehicle is a complete water-based paint system that significantly reduces solvent emissions and energy consumption during paint bake, leading to lower cure temperatures. Developed through a program with DuPont Automotive Paint & Coatings (Troy, Mich.), the system has enabled Lotus, for the first time, to hand spray a water-based Class A paint finish on a production vehicle. Lotus also claims to be the first automaker in the world to use the low-volume, solvent-free system for primer, color coat *and* clear coat. The excellent finish achieved on the *ECO Elise* prompted Lotus to convert paint operations for its production vehicles to this system by the end of 2010.

Overall, eco-enhancements shaved 71 lb/32 kg off the already trim *Elise S*. At 860 kg/1,896 lb, the *ECO Elise* achieves a combined rating of 34 mpg (15 km/liter). More impressive, given the project's comprehensive sweep, Lotus completed research, sourcing and vehicle build in only 10 weeks.

GOOD NEWS FOR ECO-WARRIORS

The *ECO Elise* made its debut July 23, 2008, at the British International Motor Show (London, U.K.). There and at subsequent European auto shows, its practical production- and near-production-ready strategies for reducing a car's carbon footprint have received an enthusiastic public and media reception at a time when, Preston points out, "the automotive industry is focusing on its environmental obligations to reduce CO₂ emissions and improve efficiencies." Lotus has blazed a technical trail that other automakers could follow to similarly reduce vehicle environmental impact.

But one question everyone seems to be asking is, *when will it be available for sale?* Lotus cautions that there is much to do before the *ECO Elise* is "ready for prime time," not the least of which is a full evaluation of hemp composite performance under real-world driving conditions.

"The intention from the very beginning of the project was to make a demonstrator vehicle and see how successfully we could integrate the different technologies," notes Preston. We are delighted with how the vehicle has turned out. We are analyzing whether to take this research program forward and how we can implement some or all of these technologies in our and maybe even our clients' cars. If we carry out the research and find it successful, there is every chance we will put the car into actual production." ■

CONTRIBUTING WRITER

Peggy Malnati covers the automotive and infrastructure beats for *CT* and provides communications services for plastics-/composites-industry clients. peggy@compositesworld.com



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