
Photo courtesy

An Acura NSX being assembled at a Honda Motor Co. facility in Marysville, OH.

Searching for the Perfect Lightweighting Recipe

Automakers, suppliers committed to lightweighting, methods vary by vehicle

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Lightweighting is so established it's now part of marketing for new vehicles. Automakers routinely detail how much less models weigh than their predecessors. General Motors Co., for example, has said a range of its vehicles is anywhere from almost 250 lb (112.5 kg) to 700 lb (315 kg) lighter. Included in the list are the Chevrolet Volt on the low end of this weight-loss range to the 2017 GMC Acadia on the high end.

Despite that, lightweighting efforts are still in their early stages. Automakers and suppliers are still far from meeting stringent fuel efficiency standards scheduled for 2025. Lightweighting is only part of achieving those standards. In addition, lightweighting strategies vary by size and type of vehicle.

"We're all looking for the perfect recipe," said Charlie Klein, GM executive director of global CO_2 strategy.

Lightweighting recipes involve materials, which in some cases mean more aluminum and magnesium as well as new advanced steels that are so strong less steel is needed. They also involve alternate ways to join pieces. That can involve adhesives and

coatings so materials that don't play well together (think steel and aluminum) don't touch. Or it can involve fewer welds or different type of welds that result in a lighter vehicle.

"I think everyone is embracing this concept of lightweighting," said Larry Brown, executive director of Lightweight Innovations for Tomorrow (LIFT; Detroit), part of the Obama administration's National Network for Manufacturing Innovation. LIFT is intended to provide companies and universities with the opportunity to collaborate on developing new lightweighting technology.

A worker at a Honda Motor Co. facility in Marysville, OH, completes installation of equipment of an Acura NSX.

Automakers and suppliers, Brown said, "recognize time is short….They're all driving to lightweighting solutions."

Lightweighting also is driving changes in the ways vehicles are developed. In North America there traditionally was a divide between designers and manufacturing personnel, said Jay Baron, president and CEO of the Center for Automotive Research (CAR; Ann Arbor, MI). The designers decided how vehicles would look while manufacturing staff figured out how to build them.

With lightweighting, there are multiple materials, which heat up and expand at different rates. That means more emphasis of designing models "for manufacturability," Baron said.

"I think we have to head in that direction," he said.

Moving Target

The impetus for lightweighting is regulatory pressure to improve fuel efficiency and reduce greenhouse gases. Regulators, with rules set in 2012, had sought the US vehicle fleet to average 54.5 mpg (23 km/l) by the 2025 model year.

In July, regulators demonstrated how difficult achieving the target will be.

The US Department of Transportation, the US Environmental Protection Agency and the California Air Resource Board filed what's known as a draft Technical Assessment Report (TAR), which covered model years 2022–2025.

The regulators said in a statement that automakers "are innovating and bringing new technology to market at a rapid pace." But inside the actual 1217-page report, the regulators also said the 54.5-mpg target for model year 2025 wasn't likely to happen under the standards. That figure assumed that two-thirds of vehicle sales would be cars and one-third trucks. Consumers, however, continue to buy more trucks than envisioned by the regulators.

The draft assessment report provided a range of 50 to 52.6 mpg (21.3–22.4 km/l), based on different scenarios for car and truck sales. The 50-mpg figure assumes 52% trucks and 48% cars while the 52.6-mpg figure assumes a mix of 62% cars and 38% trucks. In the first half of 2016, trucks accounted for almost 58% of US light-vehicle deliveries, according to Autodata Corp.

The 54.5-mpg figure "was our best estimate in 2012 of what manufacturers would, generally, produce for sale in 2025, and what their average compliance obligation would be," Jose Alberto Ucles, a spokesman for the National Highway Traffic Safety Administration, said in an e-mail. "Now that we have updated data… we have a new estimate of what manufacturers might end up building in the future."

"We're all looking for the perfect recipe."

The standards in all cases are more stringent for cars than trucks, which are larger and used to haul goods and supplies. The regulators, in their July statement, said the 2022–2025 standards "can be achieved by relying primarily on advanced gasoline vehicles."

How Recipes Vary

In some cases, lightweighting involves a lighter material such as aluminum becoming the main material.

The most prominent switch to an aluminum body was Ford Motor Co.'s F-150. Ford estimated that cut the pickup's weight by 700 lb (315 kg).

The Dearborn, MI-based automaker is extending the move to aluminum with the 2017 Super Duty (F-250 and above), which is often used for towing. Ford estimates the Super Duty's aluminum body will weigh as much as 350 lb (157.5 kg) less than the previous version. The company spent $1.3 billion at its Kentucky Truck Plant in Louisville, which produces Super Duty trucks, to handle the change in materials. The investment included a new body shop.

With the F-150 and Super Duty, only three assembly plants (two for F-150 and the Super Duty factory) were affected. The trucks are sold primarily in North America, so the supply chain is relatively compact. Also, the F-Series is Ford's highest volume vehicle line and its main source of

A coil of NanoSteel-designed high-strength steel.

profit. Thus, the investment needed to switch to an aluminum body could be supported.

The lightweighting recipe also can be more exotic with low-volume "super cars." Honda Motor Co. this year began producing its new Acura NSX at Marysville, OH. The car, with a $156,000 starting price, has an aluminum body, the same as its predecessor, which Honda discontinued in the 2000s. The previous NSX was made in Japan. Another new super car, Ford's GT, features a carbon fiber body, a material used in some race cars.

In other cases, the recipe calls for more of a mix.

GM's new Cadillac CT6 has a mix of aluminum, including the exterior, and different types of high-strength steel, including the sedan's safety cage. The luxury four-door also is the lead application for a GM-developed steel-to-aluminum spot welding process. The company has 19 patents on the hardware and controls. Among the technical challenges: There is a 900°C difference in the melting point between aluminum and steel.

Previously, steel would be spot-welded to steel or aluminum to aluminum. Steel would then be riveted to aluminum. GM says the new process eliminates the riveting step and can be used with the same welding equipment.

GM's Klein said computer aided engineering is a major part of the automaker's lightweighting efforts.

"It gives us the chance to assess different solutions," Klein said. "It allows us to go through so many iterations." Computer simulations enable engineers to determine how lightweighting steps affect a vehicle's performance, he said.

FCA US LLC's new Pacifica used high-strength steel as well as other materials, including a magnesium inner structure in the liftgate, to cut 113 kg from the minivan, including 76 kg from its body.

"In a general sense, our strategy we've been pursuing is to predominantly stay with steel for body structures and use alterative materials in closure panels," said Jeff Tibbenham, who supervises body in white engineers at FCA.

FCA also uses computer models. "We take those models," Tibbenham said. "We substitute different materials for the different applications. We make thousands of computational runs. It's a very upfront and early development process. Slowly, we arrive at what is the most optimal solution."

The Pacifica was one of the first models developed this way, he said. "This is the footprint for our development going forward."

In the end, the Pacifica included aluminum engine brackets and rear upper shock mounts and a high-strength steel front suspension cradle.

Automakers also are finding ways to reduce the number of parts. With the Cadillac CT6, the automaker employed high-pressure die castings to improve stiffness. That enabled GM "to remove 190 or so parts because we could do it in a single casting," said GM's Klein.

Role of Suppliers

Lightweighting is a big priority for suppliers, who are finding themselves coordinating earlier with vehicle makers.

At FCA, representatives of two steel suppliers are "really in house with us," Tibbenham said. "They come to us with new materials and say, 'What if?' Our job is to package and engineer vehicles. Having their engineers, they interact daily with my engineers. That's been a great asset to use." Tibbenham declined to identify the steel companies involved.

Gestamp (Madrid), a maker of metal automotive components, co-developed a rear rail system made from high-strength steel with Honda for the Civic. Energy from a crash is absorbed by system components.

"You have to do the design much earlier," said Paul Belanger, Gestamp's director of research and development for body in white. "We have to be joined at the hip for this to be successful. We were in there one, two years before the typical time we would have been sourced."

The system, which includes "soft zones," folds "in a snake fashion" in a collision, he said.

"It is clearly a marathon."

Gestamp is studying new production methods to reduce weight. The company is looking at 3D laser cladding which melts powder or wire and builds up material "exactly where you need it to be," Belanger said. That's not yet ready for production, he said.

Safety requirements "keep going up and up," which make it harder to reduce vehicle weight, Belanger said. "That's why you have to utilize innovations."

Lacks Enterprises Inc. (Grand Rapids, MI) has developed an automotive wheel that the company estimates is 10 lb (4.5 kg) lighter than a typical 40 lb (18-kg) wheel. Lacks cut the weight by designing a lighter aluminum inner structure. Foam is then injected between the interior structure and the composite surface.

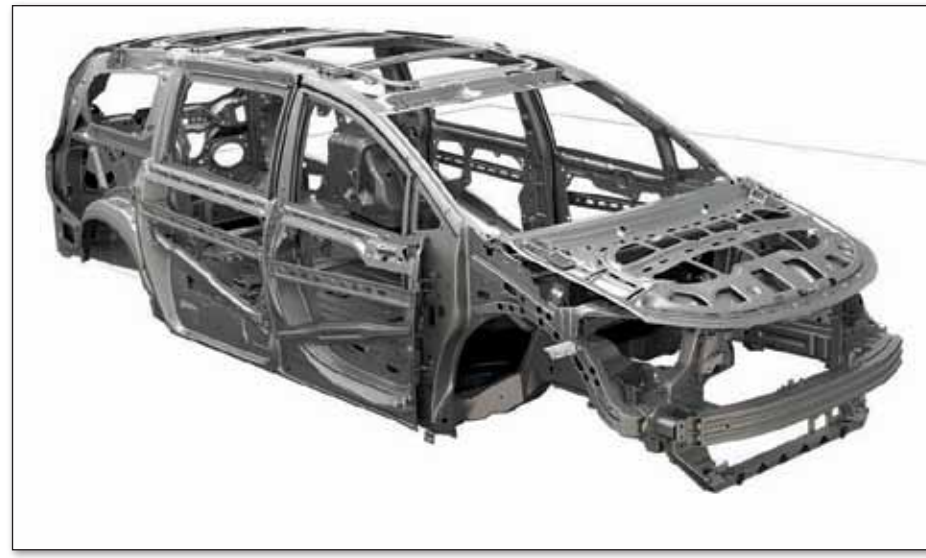
The foam ensures there aren't openings in the wheel, said James Ardern, general manager of Lacks Wheel Trim Systems.

Ford Motor Co. has converted its Super Duty line of pickups to aluminum body panels, similar to the F-150.

Lacks had concentrated on finishes for automotive grilles and trim. "From 1998 to 2012, our product was used predominantly for how it looked," Ardern said.

"Then we started to realize in 2010, when we saw the lightweighting push, fundamentally our approach was very good for delivering lightweighting….If there hadn't been this (fuel efficiency) target out there, we could still be heavily focused on finishes."

Ardern said Lacks' lighter wheel currently is on the Ram 1500 Big Horn truck.



A body in white for the multi-material Chrysler Pacifica minivan.

Rassini Frenos (Mexico City), a producer of brake rotors, has been working with customers on lightweighting issues. The company's "first wave" of lightweighting was to have a ductile aluminum brake hat, said Mauricio Gonzalez, engineering director for advanced brakes at Rassini's Plymouth, MI, product development office.

The next phase, "that needs to happen around 2020," involves reducing the weight of the breaking surfaces with new composite materials that Rassini is trying to develop, he said.

What's Coming

NanoSteel (Providence, RI) designs alloys and licenses them to steel companies. NanoSteel-designed steels for automotive applications are currently being tested for metal fatigue and welding. "We're very encouraged by the tests," said Craig Parsons, president of automotive for NanoSteel. "People have talked about this high-strength and high-formability material for a long time."

It will still take years before such steel shows up in production vehicles. In a follow-up e-mail, he said, "We are excited to work with the OEMs over the next several years to design the material into production vehicles."

LIFT is beginning to gain momentum. The manufacturing innovation institute is acquiring about $10 million in equipment to be used for lightweighting projects, Brown, the executive director, said. The electrical system of LIFT's Detroit headquarters is being improved to ensure it can handle the load for the new equipment.

"We're talking about equipment to do pilot-scale development," Brown said. Another one of the NNMI groups, the Institute for Advanced Composites Manufacturing Innovation (Knoxville, TN) has a satellite office at LIFT. Both will work together on lightweighting-related projects.

Industry groups for steel and aluminum say their members will be involved in lightweighting far beyond 2025.

"I don't think there's going to be an end" to the lightweighting drive, said Jody Hall, vice president for automotive market of the Steel Market Development Institute.

The industry faces "the never-ending quest for better," said Doug Richman, chairman of the aluminum transportation technology committee of the Aluminum Association. "The brilliant breakthrough five years ago is now the industry norm and five years from now will be obsolete."

Indeed, lightweighting increasingly is seen as a marathon, rather than a sprint to meet the 2025 model year standards.

"The technologies that get us to 2025 are different than the ones that get us to 2050," CAR's Jay Baron said. "It is clearly a marathon."

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