composites: Multiple strengths, infinite possibilities

While the materials that vie for automotive use seem to change every year — with some growing in popularity as others fade — engineered composites have enjoyed consistent growth in both pounds of materials used and the variety of components represented. Here, we take a look at the reasons for their success.

In the automotive world, materials selection is one of the most crucial and written about design decisions made for any automotive component — because of both its financial influence and its technical impact.

While all but the most exotic body panels were once automatically specified in steel, more and more exterior components are now composites. Still, composites aren't limited to vehicle exteriors. They're finding their way into the interior and into structural components throughout the vehicle.

The key to the growth of engineered composites' use in cars and light and heavy trucks is a combination of their engineering flexibility, cost, and continuously improving manufacturing adaptability.

Their performance characteristics can be custom-tailored for specific applications, and their aesthetics can be matched to any other visible component. They offer substantial benefits to both the manufacturer and the ultimate vehicle owner.

Reduced Weight

One of the primary reasons any design team begins to investigate composites for a specific vehicle application is weight reduction. Composites typically reduce component weight by about 35%, compared with steel of equivalent structural performance. Reduced weight brings obvious advantages, including better fuel economy, better vehicle performance, and reduced emissions.

Advances in low-density and ultra-low-density sheet-molded composites (SMC) offer even further application potential, matching or even surpassing aluminum in weight reduction and strength, typically at lower overall cost.

Manufacturers can benefit by producing vehicles with better EPA mileage ratings and better emissions, while vehicle owners enjoy lower operating costs based on improved fuel economy.

Virtually Flawless Surface Finish

With today's surface-finishing technologies, composites offer aesthetics that match virtually any alternative material.

"Tough Class A" (TCA™) sheet-molded composite and composites using high-performance UV sealers provide nearly flawless surface quality, improved impact resistance, and paintability equal to steel's.

The use of these techniques, as well as some of the newer primers, reduces microcracking (the precursor to paint "pops" caused by outgassing during high-temperature paint curing operations) to a level where the number of defects per thousand parts also matches that of steel.

Composites Go More Than "Skin" Deep

Refinements to the engineering and manufacture of composites have allowed them to be applied more and more to structural vehicle components.

Composites now see service as grille opening reinforcements, bumper beams, head lamp carriers, loadfloors, cross-vehicle beams, and tailgate and midgate reinforcements.

Composites Under Hood and Vehicle

Composites can also be specified for underhood duty as valve covers, and as cam, timing chain and engine covers. Composite valve covers withstand underhood temperatures at the exhaust manifold of 450°F (232°C), and offer light weight, while costing substantially less than magnesium or aluminum.

Other underhood and under-vehicle applications include fuel tank heat shields, transfer and front axle skid plates, exhaust heat shields, radiator bracket supports, and evaporator canister brackets.

Molding Process Cuts Parts Counts

Since composites are molded parts, they also lend themselves to parts consolidation. Intricate details, difficult to execute in steel, can be molded into the composite part during normal fabrication, allowing design refinements often impractical with other materials. And assembly fixtures are typically simpler, if required at all.

All of this translates into a faster time to market, with lower manufacturing costs and simpler procedures.

Toyota Tacoma Sports New Composite Box

Once associated only with sports cars and other specialty vehicles, over the last few years, composites have gone mainstream. Nothing makes more of a point of this than the new composite pickup box adopted by Toyota for its totally new Tacoma.

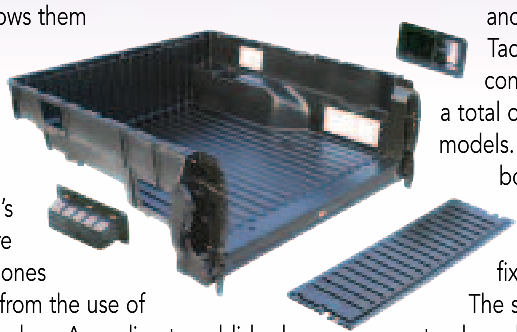
After ten years, Toyota engineers have completely redesigned the Tacoma for 2005, adding a host of innovative features. Not the least of these is a new, one-piece, sheet-molded-composite (SMC) box that will come standard on every Tacoma.

The new box has worked out so well that it has become the star of one of Toyota's new 30-second TV spots promoting its Tacoma line, dramatically portraying the box's ability to withstand adverse treatment.

While the treatment shown in the commercial may not represent the behavior of normal pickup owners, the box has been designed to soak up the abuse that typical real-world pickup users do often heap on their vehicles.

The fiberglass-reinforced polymer composite has been tested for resistance to all vehicle fluids, as well as for resistance to most of the materials that might find their way into the box as cargo. That list includes kerosene, garden chemicals, and the like.

For the consumer, the advantages of the composite inner box are clear. Composites resist corrosion much better than steel, have much greater impact resistance, and are much less prone to damage from scoring, scraping and creasing — so the box will stand up to rough service and exposure to the elements. At the same time, the composite box eliminates the need for customers to spend another few hundred dollars for an aftermarket bed liner, and allows them to spend more for factory options and accessories.



But Toyota's customers are not the only ones who benefit from the use of the composite box. According to published reports, Toyota has reduced the weight of the box inner by 10%, and slashed its tooling costs by 50% compared with traditional steel box construction. Tooling completion time is also at least 15 weeks faster, offering the potential to dramatically shorten time to launch.

The box is a specially reinforced, structural-grade, sheet-molded composite. When both fiberglass and reinforcing additive are accounted for, the finished composite is 70% mineral by volume.

Manufactured by ThyssenKrupp-Budd in a facility especially designed and built for the purpose, box production volume is scheduled at 180,000 units in the first model year.

The boxes will be supplied in two different lengths — 5.25 ft. (the "short deck" in Toyota parlance) and 6.5 ft. (the "long deck"). The two deck lengths will be mixed and matched with various Tacoma cab and drivetrain configurations, to generate a total of 18 different Tacoma models. Yet the full 180,000 box inners can be produced with only three molds; no assembly fixtures are required.

The single-piece SMC box not only replaces a half-dozen traditional steel subpanels, but the mold can easily be shaped to accommodate a variety of accessories, like openings in the sidewalls for lockable storage compartments, plus a provision for mounting a 400W, 110V outlet box in the cargo area, all without additional tooling or assembly fixture requirements.

Compression-molded in one piece from black SMC, the box inner is formed in one mold cycle, then machined and painted with a matte black protective coat. A grained, nonskid surface is integrally molded into the box floor. A matching tailgate liner offers composite-level protection to the inner surface of the tailgate.

A Peak at the Future: 2006 Honda Ridgeline to Feature High-Strength Composite Materials

The 2006 Ridgeline, Honda's all-new 4-door 4WD truck, will feature extensive use of high-strength composites when it goes on sale in Spring 2005.

The truck's 5-foot bed includes a compression-molded-SMC floor, headboard, and side-panels. Additional technical details about the Ridgeline's innovative rear bed will be unveiled when the truck makes its world debut at the 2005 North American International Auto Show.

Honda selected composites for durability, styling, and low mass. Gary Flint, Honda R&D Americas' Chief Engineer, stated "SMC allowed Honda to integrate features into the bed floor that would not have been cost effective with conventional steel. Also, SMC offers greater resistance to dents, higher impact strength and 100% resistance to corrosion.

Honda worked with Meridian Automotive Systems in developing the Ridgeline. Meridian will be molding, assembling, and painting the bed components and assemblies. Special resins are used in the SMC formulations developed to meet the Ridgeline's world-class durability requirements.

Composites in the New Cadillac SRX Make the Sky the Limit

When GM needed to develop a new kind of window frame for its SRX, the design team turned to composites.

The window frame is a full-roof-length, rectangular frame fabricated of SMC by Molded Fiber Glass Companies, and fastened to the surrounding structure with epoxy adhesive.

The frame, which consolidates a substantial number of parts into one assembly, serves as the supporting structure for the dual, independently operating sun roofs (2) that open the roof of this new SUV to the sky. The frame subassembly contains 83 brass inserts that act as attachment points for the sunroof operating motors, the window tracks, the glass rear window hinges, the sunshade and the wind dam.

The New Corvette Continues Its Composites Tradition

While composites have gone mainstream and applications have continued to expand, the roots of automotive composites still grow out of one of the world's pre-eminent sports cars — the Chevrolet Corvette.

The 6th generation Corvette, coded C6, uses lightweight composites for all of its exterior Class A body panels, continuing the long GM and Corvette tradition.

For programs of the Corvette's volume, roughly 35,000 units annually, composite materials offer solutions to many of the challenges faced by an OEM program team. Their light weight, low tooling investment, design flexibility, corrosion resistance, and dimensional stability provide an insurmountable business case for composites. Composite components for the C6 are provided primarily by Meridian Automotive Systems and TK-Budd.

Flare for Composites: New Dodge Ram Heavy Duty

The 2005 Dodge Ram "Dually" — biggest of all Dodge pickups — will feature an all-new composite rear "extended" fender to accommodate the extra width of its tandem rear wheels.

Low tooling investment, excellent Class A finish, and dimension stability led the value proposition for this decision, as well as Meridian's ability to supply the parts, top coated, from its own plant in Celeya, Mexico, to DCX's Mexican assembly plant.

Success = Hummer H2 SUT

Based on the Hummer H2's success, GM has expanded the H2 family for 2005. The newest model? The H2 Sports Utility Truck (SUT) — basically an H2 with an open bed. Supplied by Meridian, the endgate features an SRIM composite inner panel and an SMC composite outer panel. The midgate, a removable panel separating the passenger compartment from the rear bed, uses an SMC outer. First used on the Chevrolet Avalanche, this design has proved to be very durable, lightweight, and cost effective.

Composites Offer An Array of Manufacturing Variants

Composites manufacturing techniques continue to advance. Composites are now available as sheet-molding composites (SMC), bulk-molding composites (BMC), reinforced reaction injection-molding (RRIM) composites, structural reaction injection-molding (SRIM) composites, resin transfer molding (RTM) composites, and liquid compression molding (LCM) composites.

SMC applications include door surrounds and door assemblies on the Corvette and Cadillac XLR to the sunshade on the Town Car to the grille opening reinforcement on the Ford F150 to the engine cover on the Dodge Caravan and the fuel tank heat shield on the Dakota.

Components made of BMC are used for valve covers, cam and timing chain covers on a variety of engines built by Ford, Chevrolet, and Daimler Chrysler. Other BMC structural components include grille opening reinforcements for Ford Crown Victoria and Mustang, and Lincoln Town Car and Continental.

The Chevrolet Corvette uses LCM composites in underbody panels, floor boards, dash, and lower and upper plenums. LCM is also used for the raised roof, the rain tray, hood and half fenders for several Freightliner heavy-duty truck models, for door apertures and crossmembers for the Kenworth T-2000, and for the roof panel assembly on the Peterbilt 387.

The Chrysler Concorde and Dodge Viper use RRIM front fascia panels, as do the Ford Crown Victoria and Mercury Grand Marquis. RRIM is also used for the front and rear fenders of the Cadillac XLR, and the fenders and front and rear fascia of the Corvette, as well as dually fender flares for Dodge Ram, Ford F350, and Chevrolet Silverado.

RTM is used primarily for heavy-duty truck components like the cowl and A-pillars of the Freightliner Heavy Duty, the hood of the Freightliner MTVR and the bumper of the Kenworth HDT.

SRIM is used on both the Chevrolet Avalanche's and Cadillac EXT's midgate, and on the Hummer H2 SUT's endgate.

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