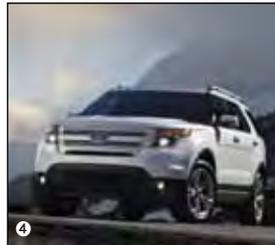


Magnesium Components Blazing New Trails for Automakers

Hot off the auto show floor, new cars and sport utility vehicles (SUVs) are benefiting from years of magnesium alloy and forming research and development. Critical research and development is identifying and implementing the enabling technologies that allow internal and structural components to significantly reduce vehicle weight. Materials engineers are driving lightweighting innovations by selecting magnesium from among a core group of advanced materials to form lighter components that produce environmentally and performance-conscious vehicles. As automotive engineers redesign an entire industry, strategic use of magnesium components facilitates this exciting transformation.



Automotive manufacturers use lightweight magnesium structures that join advanced technologies with better fuel economy. Shown: ❶ Acura ZDX, ❷ Jeep Grand Cherokee, ❸ Chevrolet Corvette Z06, ❹ Ford Explorer, and ❺ VW Golf. © Photos (respectively) courtesy of Acura, Chrysler Group LLC, General Motors Corp., Ford Motor Company, and Volkswagen AG. Used with permission.

Magnesium R&D Enabling Lighter Cars

The U.S. Automotive Materials Partnership (USAMP) is a consortium of the U.S. Council for Automotive Research (USCAR) based in Southfield, Michigan, composed of Ford Motor Company, General Motors Corporation, and Chrysler Group LLC. On the materials side, USAMP research focuses on magnesium's mechanical and yield properties, along with other advanced materials.

Their research includes alloy development to seek rare earth additions to strengthen magnesium in its secondary phase; improving ductility, tensile strength, elongation, and process parameters to enable new breakthroughs in automotive magnesium applications. On the process and manufacturing side, USCAR focuses on achieving high-pressure die casting success, while super-vacuum die casting of magnesium is in development. Improvements in magnesium extrusion rates and twin roll cast magnesium sheet technology are underway to offer magnesium as a preferred lightweight option for structural automotive components.

USCAR's 2010 Chairman, Matthew Zaluzec of Ford Motor Company, says that magnesium is a key material for lightweighting vehicles. He views lightweighting with magnesium as both an opportunity to allow larger-sized vehicles to be powered by smaller-sized batteries, and as a way to enable reduced vehicle size along with reduced weight. "For automotive lightweighting and materials engineers, magnesium is the means to an end. Powertrains are keys to vehicle fuel economy, but will not reach fuel economy targets alone. Magnesium is playing a major role in vehicle lightweighting, since new magnesium applications factor into body structures as well as powertrains."

Zaluzec asserts that advanced technology cars must essentially incorporate the best mix of all metals and materials to achieve Corporate Average Fuel Economy (CAFE) and safety standards, and greenhouse gas (carbon dioxide) reduction goals. USCAR research identifies cost-effective ways to integrate magnesium parts with other light materials that work well for mass production. Says Zaluzec, "Magnesium subassemblies and interior components are being integrated with other materials, and we're looking for ways to put more structural magnesium parts on cars as a lightweighting solution."



The iconic Chevrolet Corvette takes full advantage of lighter, stronger magnesium to achieve top performance. © Photo courtesy of Chevrolet. Used with permission.

integrate with other (mainly aluminum) components. The magnesium engine cradle transcends all Corvettes, so it is central to the car's stiff, lightweight structure and is fundamental to overall performance." Steering gear attachments are also integrated into the cradle, improving vehicle responsiveness. The single-piece die-cast engine cradle is made from Norsk Hydro's patented high-temperature magnesium alloy AE44, which provides excellent elongation properties and increased yield strength. Meridian Lightweight Technologies, Inc., Strathroy, Ontario, has achieved about 33 percent weight savings in the Corvette's 24-pound (10.85 kilogram) magnesium engine cradle.

Magnesium Engine Cradle Rocks an Icon

The world-renowned Chevrolet Corvette has achieved what Chevrolet's David Caldwell says is "the ideal mosaic of lightweight materials," which includes its magnesium engine cradle. At 3,175 pounds, the Z06 is Corvette's lightest high-performance model. Magnesium helps to achieve the car's lower weight targets, while improving fuel economy and providing a very stiff and strong structure.

Caldwell notes magnesium's role in Corvette's success: "The magnesium engine cradle is very important as the mounting point for many of the front suspension components that



The AE44 magnesium engine cradle is the industry's first magnesium high-pressure die cast chassis component. © Photo courtesy of Meridian Lightweight Technologies Inc. Used with permission.

Magnesium through the Roof



Ultra-light magnesium fixed roof components provide unyielding stiffness without affecting the Z06's low center of gravity. © Photo courtesy of Thixomat. Used with permission.

The Corvette Z06's fixed roof structure is all about mass. Notes Caldwell, "Weight is the key to all things Corvette, and that concern is even more crucial for areas that are located so high in the car's body and structure. Minimizing mass in the roof area is even more important." Magnesium roof components are essential to keeping the vehicle's center of gravity low, while adding extra structural stiffness.

Thixomold® structural and cosmetic magnesium parts used in the Corvette's roof for its hard top and soft top convertibles are made by Thixomat, Ann Arbor, Michigan. Fourteen Thixomold parts and 19 assembled parts are formed in thin-walled shapes with excellent dimensional repeatability, ductility and surface quality to near net-shapes with little or no machining required. No sulphur hexafluoride (SF6) cover gas is used, and no dross or sludge is produced in the Thixomold process, making it an eco-friendly way to make precision automotive parts. Buffing and polishing steps are eliminated, and E-coat and/or powder coat paint are applied. Subassemblies are produced for Magna Car Top Systems of America in Troy, Michigan.

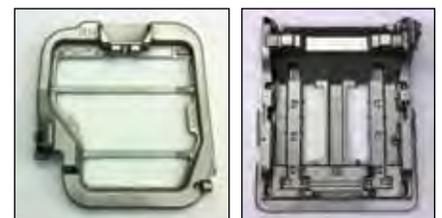
Best Seats in the House are Magnesium



The Explorer (left) uses lightweight magnesium third-row seats (right) in both manual and power versions. © Photos courtesy of Ford Motor Company. Used with permission.

The re-invented Ford Explorer, the 2011 North American Truck of the Year, uses magnesium seat frames for its third-row passenger seats. Strategic magnesium use supports Ford Motor Company's commitment to vehicle quality, reliability, fuel efficiency, safety, smart design, and affordability. "We're doing a lot of work with magnesium, which is the lightest weight metallic element for both powertrain and body applications," says Ford senior technical leader John Allison. (See Lincoln MKT magnesium liftgate inner, *Magnesium Showcase Issue 12, Spring 2010.*)

Magnesium third-row seat framing shaves off pounds while retaining essential strength. Ford's supervisor of rear seat structures, Paul Ferraiuolo, notes: "We use magnesium for its light weight and structural capabilities, giving the seats strength without sacrificing quality. Explorer's third row seats fold and spin back into the underbody, and are offered in manual and power versions. In manual mode, lighter magnesium provides greater ease of use. In the power version, magnesium enables us to use the optimum number and type of motors, which also keeps weight down. The cast magnesium frame forms a part that directly interfaces with its mating components using integral latches. There is definitely a place for magnesium in seating applications, and in non-load-bearing components."



Magnesium third-row seat framing optimizes strength and functionality without adding weight. © Photos courtesy of Meridian Lightweight Technologies, Inc. Used with permission.

Rugged Magnesium Panel Supports Interior Redesign

As the Chrysler Group LLC, Auburn Hills, Michigan celebrates the 70th anniversary of its iconic Jeep brand, magnesium is playing an important role in the redesigned interiors of Grand Cherokee, Wrangler, Liberty, Compass, and Patriot. Jeep's redesigned instrument panels are configured as a single-piece magnesium die casting that anchors the dash with improved ergonomics and rich, upgraded materials. "The 2011 Jeep Grand Cherokee is another proud graduate of our Advanced Interior Design Studio," says Ralph Gilles,



The Grand Cherokee's magnesium instrument panel has improved durability and lighter weight, connecting to navigation, safety and audio systems. © Photo courtesy of Chrysler Group, LLC. Used with permission.

Senior V.P. Product Design for Chrysler Group LLC. Jeep's magnesium instrument panel houses advanced technology and hands-free connectivity to safely communicate, navigate and select entertainment.

Magnesium was chosen for the main instrument panel component as the best way to facilitate the new interior design. Jeep's Klaus Busse notes, "Magnesium is the structure used underneath the skin. It's a great material because of its light weight, and can be cast into the desired shape, allowing great packaging and therefore, design flexibility. The alternative steel beam is cheaper, but offers no design flexibility." Using lighter weight materials such as the magnesium instrument panel helps the premium sport utility achieve improved fuel efficiency of 23mpg highway.



The Jeep Grand Cherokee makes strategic use of lightweight magnesium in its interior redesign. © Photo courtesy of Chrysler Group LLC. Used with permission.

Magnesium Shifts into High Gear

The 2011 Acura ZDX maximizes magnesium's rigid strength in its shifter support bracket – a workhorse component that is called upon to endure heavy use. Acura engineers chose magnesium for key benefits, as ZDX Senior Chassis Design Engineer Shawn Kelly explains, "In selecting the material for the Acura ZDX shift select lever bracket, we balanced the objectives of light



The Acura ZDX (left) uses a lighter magnesium shifter support bracket beneath the shifter (right) that has twice the stiffness of its welded steel counterpart. © Photos courtesy of Acura. Used with permission.

weight, stiffness and part integration. Due to a relatively low amortization volume, tooling cost was also an important consideration. The ZDX floor layout and tight confines of the center console presented a significant design challenge. When we investigated material options, magnesium quickly became the standout choice based on its high stiffness-to-weight ratio, ability to be cast in complex shapes and low tooling cost."

According to David R. Greer Jr., Business Development Manager for Meridian Lightweight Technologies Inc., the magnesium shifter support bracket yielded a 50 percent weight savings over the steel part it replaced. The support bracket dimensionally locates the IP trim and shifter support, and provides key lateral stiffness to improve the shifter's feel, fitting directly underneath the drive shifter. "The magnesium support bracket exhibits superior stiffness in a much lighter solution than a multi-piece, welded steel assembly. We use AM60D magnesium alloy in a single-piece casting that has twice the stiffness of its predecessor. This magnesium application is a platform upon which many additional interior car components will be based. Lightweight magnesium parts are accomplishing lightweighting goals without sacrificing strength, so that durability, quality and safety will go hand-in-hand with fuel economy and environmental targets," says Greer.

Ultra-Light Magnesium Gearbox Housing

Volkswagen AG, Wolfsburg, Germany, continues to pioneer automotive magnesium, citing the need to make multi-material constructions in mass-produced vehicles more affordable. A prime example of their lightweight construction applications is the VW Golf's magnesium gearbox housing, a modular system consisting of the magnesium gearbox housing and magnesium clutch housing. The Golf's magnesium gearbox and clutch housing's modular construction facilitates increased functionality post-assembly, and weighs 25 percent less than the previous aluminum-magnesium alloy used, with fixing points for the mounting bracket at the top of the housing, and attachment points for self-aligning bearing supports at the housing's bottom.



The magnesium gearbox and clutch housing unit is used with VW engines, including the Golf. © Photos courtesy of Volkswagen AG. Used with permission.

A Closer Look: Magnesium Casting Technologies

Twin Roll Cast Magnesium Sheet makes Lighter Auto Panels

The Commonwealth Scientific and Industrial Research Organization (CSIRO) Materials Science and Engineering Division, Clayton, Australia, creators of T-Mag integrated casting technology (see *Magnesium Showcase* Issue 7, January 2009), is riding a wave of new casting technology development. Their patented twin roll casting process for magnesium sheet has been selected by USCAR as a suitable technology for production of lightweight structural automobile components. Years of leading-edge research and testing has created twin roll cast magnesium sheet directly from molten metal, which is comparable to direct chill cast sheet but with reduced flow stress. Twin roll casting is proving a quick and efficient way to eliminate repeated rolling and annealing used in conventional sheet manufacturing methods, generating a 50 percent reduction in greenhouse gas emissions.



CSIRO's production-scale casting machine is a more time and cost efficient way to produce magnesium sheet. © Photo courtesy of CSIRO Australia. Used with permission.

The twin roll casting machine produces magnesium sheet down to 3 millimeters (mm) thick and up to 600mm wide with excellent sheet profile control using standard ASTM alloys and new magnesium wrought alloys. CSIRO's thermal exposure and tensile property tests of magnesium alloy AZ31B twin roll cast sheet show it is comparable to annealed AA5083 aluminum sheet, suggesting that same-gauge substitution of magnesium panels for aluminum may now be a viable option for lightweighting vehicles.

CSIRO's twin roll casting technology potentially saves up to 60 percent in cost over current processes, enabling cost-competitive magnesium sheet applications to be developed in the automotive sector. An industrial-scale twin roll casting pilot plant is conducting trial runs of high-end 3mm magnesium alloy sheet. Coils of fabrication-ready, as-cast twin roll material are being evaluated. The CSIRO Light Metals Flagship is poised to use twin roll casting technology to grow the magnesium sheet market to several hundred thousand metric tons per year over the next 10 to 15 years.

ATM Die Casting Steers Magnesium in Green Direction

Advanced Thixotropic Metallurgy (ATM), CSIRO's environmentally-friendly approach to high-pressure die casting (HPDC) technology, uses a revolutionary feed system for forcing molten metal into dies that reduces greenhouse gas emissions, cuts the cost of casting metal parts, and improves their quality, strength and ductility. ATM technology has been licensed by Bridgestone Toyota Gosei for production of die cast magnesium steering wheels for Australian vehicles. The ATM method is less costly to operate than conventional HPDC and the new runner system can be fitted into existing equipment.

CSIRO's ATM Project Manager, Dr. Rob O'Donnell, describes ATM process benefits: "The ATM feed system involves a radical redesign of the runners. This makes a product with more uniform distribution of nucleation sites, reduced porosity, and a lower unit price than traditional casting. We influence molten metal flow behavior, the fill pattern of the die, and subsequent solidification. By changing the way molten metal is delivered to the die, we take advantage of the high pressure inherent in the process to make castings with finer microstructure and lower porosity." Low porosity enables the end product to be heat-treated. This significantly increases metal pliability, which potentially more than doubles product strength – impossible in traditional HPDC products. Says O'Donnell, "We have the opportunity to manipulate microstructure, so that where strength is critical, lighter parts can be designed to perform the same task."

CSIRO Light Metals Flagship researchers are enabling higher quality castings by changing runner architecture where molten metal flows into the die, and the gate opening into the die cavity. The ATM melt delivery system reduces energy costs, uses and wastes less metal, improves melt flow, and dies do not require pre-heating to as high a temperature. Die casting professionals believe that ATM technology has real-world relevance for the HPDC industry's future. The patented ATM technique potentially increases manufacturing efficiency and improves the integrity of magnesium automotive components. CSIRO's work in pioneering magnesium forming and processing technologies and collaborating with USCAR is vital to automotive engineers achieving ever-higher levels of practical application.

Automotive OEMs and suppliers, IMA members, magnesium researchers, processors, fabricators, and parts manufacturers are all active stakeholders in vehicles made lighter with magnesium. As advancements in enabling technologies continue, drivers everywhere will reap the benefits of magnesium-intensified vehicles for years to come.



The ATM die casting process for this magnesium steering wheel armature uses a revolutionary feed system that is well-suited to magnesium. © Photo courtesy of CSIRO Australia. Used with permission.



To learn more about the benefits of designing products with magnesium, contact the **International Magnesium Association**
1000 N. Rand Road, Suite 214, Wauconda, IL 60084 USA
Tel. 847.526.2010 • Fax 847.526.3993 • E-mail: info@intlmg.org • www.intlmg.org

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