

IMA Award Winners Spotlight Magnesium Innovation

The 2012 IMA Awards of Excellence recognize exceptional achievement in the global advancement of magnesium products and processes, and the IMA Environmental Responsibility Award acknowledges efforts to substantially reduce greenhouse gas emissions and environmental footprint via fundamental changes in process and energy used to power magnesium operations.

Dual Role for Magnesium Housing in Automotive LED Lighting

The IMA Award of Excellence winner in the Cast Product Automotive category is Aristo-Cast, Inc., Almont, Michigan, USA, for their ultra-lightweight, high efficiency LED light housing that serves as both lamp enclosure and heat sink. The integrated LED housing design yields major weight savings while acting as a heat sink for heat removal and transfer for high-powered automotive LED lights.

Magnesium alloy AZ91E is used in the investment casting process. Investment casting for the LED housing uses wax patterns produced in-house, following the same process as for production wax. The three-dimensional solid model produced is then attached to a sprue/tree where it begins the ceramic shell building process, including dips into a slurry and silica sand to make the ceramic shell. The shell goes through autoclaving (pressure and steam) to remove the wax pattern, creating the ceramic mold into which the molten magnesium is poured. The process enables achievement of extremely thin-walled sections that are repeatable as thin as 0.5mm (0.020 inches) to further reduce the component's material content. Importantly for LED applications, the process allows a sufficiently smooth surface finish that yields a Class A reflective interior light surface.



Aristo-Cast automotive LED lights are housed in magnesium alloy AZ91E, helping to achieve lighter-weight, fuel-efficient vehicles. © Photo courtesy of Aristo-Cast, Inc. Used with permission.



Magnesium combined with investment casting yields a high-powered LED light with integral heat sink, creating high-performance LED automotive lighting. © Photos courtesy of Aristo-Cast, Inc. Used with permission.

Aristo-Cast Vice President and Engineer Paul Leonard elaborates on the LED housing's design: "Since no draft is required as with most other casting processes, this magnesium LED housing achieves optimum lightness and contributes to overall vehicle weight savings. The ultra-light high-efficiency LED lighting design is proving to be consistently less than half the weight of competitive LED products. The magnesium construction enables our LED lamp enclosure to integrate the heat sink within the same part, which is critical to effectively cooling a high-powered LED to avoid performance failure."

Aristo-Cast's integrated LED lighting design and construction utilizes a winning combination of magnesium alloy and investment casting that result in a durable and reliable LED light that meets the automotive industry's demanding energy-efficient, lighter-weight platform.

Portable Magnesium-Housed Chemical Identification and Analysis System



The GUARDION™ Gas Chromatography/Mass Spectrometry chemical identification and analysis unit is portable and sealed in a rugged magnesium housing/cover. © Photo courtesy of Twin City Die Castings Company and Smiths Detection & Nexus Design. Used with permission.

Winning the Cast Product Commercial (non-automotive) category is Smiths Detection and Nexus Design, Danbury, Connecticut, USA, for the die-cast magnesium enclosure and housing cover for their GUARDION™ next-generation portable Gas Chromatography/Mass Spectrometry (GC/MS) chemical identifier and mixture analysis system. The lightweight, compact system provides rugged field operation in hot zones and extreme environments. The GC/MS system identifies single or multiple substances within complex chemical samples using a universal, broad-based sample collection and injection technique to identify volatile and semi-volatile organic compounds in gases, vapors, liquids, and solids.

Magnesium alloy AZ91D, cast by Twin City Die Castings Company, Minneapolis, Minnesota, USA, forms the GUARDION's housing, designed with internal heat sink pins (0.50 inches (12.7mm) high) as an integral part of the casting using an internal lift. A large center opening allows both a lift and a center gated casting to aid fill on fins and pins. A minimum draft on all casting features keeps housing weight under design limits.

The magnesium cover casting features deep, internal bosses with minimum draft, making the casting nearly equal in surface area between the inside and outside, achieved by applying a double ejector system to both the ejector half and cover half cavities.

The GUARDION's top plate design required added ribs to meet heat sink requirements, and externally edge gated for fill. The main enclosure is center gated with an internal lift for 146 pins. Both the top plate and the main enclosure have limited draft of one degree per side on fins, as well as a thin-wall design to minimize housing weight. The magnesium top plate weighs just 2.92 pounds (1.32kg), and the main enclosure weighs 3.05 pounds (1.38kg), and are both cast using a Buhler 84 DL cast machine.

The integrated as-cast, magnesium alloy housing is superior to the alternate method of casting pins as a separate piece to be fastened to the main casting, which adds cost and yields inferior heat sink properties. Smiths Detection Senior Mechanical Design Engineer David D. Manning explains, "In addition to cost and weight savings, integrating the heat sink with the enclosure eliminates the need for precise machining and the additional complexity required to achieve intimate thermal contact with the enclosure surface, and eliminates an additional thermal resistance associated with the mechanical interface of multiple components. The resulting integrated unit helps to maximize the overall efficiency of the heat exchanger system, and allows this sealed instrument to operate at extreme environmental temperatures."



Clockwise: The outside of GUARDION's top plate casting with fins and minimum draft on all features (top left); the inside cover casting with integral heat sink (top right); the main housing casting with integral heat sink (bottom right); and housing and cover castings together (bottom left). © Photos courtesy of Twin City Die Castings Company and Smiths Detection & Nexus Design. Used with permission.



A hazardous materials technician identifies chemicals from a waste products spill at an industrial site. © Photo courtesy of Smiths Detection. Used with permission.

The magnesium housing protects the advanced technologies within, including the low thermal mass gas chromatography (GC) technology, miniaturized toroidal ion trap mass spectrometer (MS), rechargeable lithium-ion battery, and embedded software. The portable, sealed system operates in extreme temperatures ranging from 32°F to 113°F (0°C to 45°C) and relative humidity from 0 to 95 percent.

Smiths Detection Senior Product Manager Kenneth J. Fredeen, Ph.D., notes the device's many critical applications: "The GUARDION is used by military and civilian emergency responders, ground force expeditionary teams and bioenvironmental engineers, for detection and identification of chemical warfare agents (CWA), toxic industrial chemicals, pesticides, drugs, and environmental pollutants to assess contamination, confirm CWAs detected by other devices, identify contents of suspicious packages and leaking containers, and for sick building investigations and clandestine laboratory evidence screening."

DC Slab Casting Technology for High-Strength Magnesium Alloys

The IMA Award of Excellence winner in Process is Magnesium-Elektron UK, Swinton, Manchester, UK, and Magnesium-Elektron North America, Madison, Illinois, USA, for developing direct chill (DC) slab casting technology to enable high-strength magnesium alloys to form the magnesium plate to be used in applications such as commercial aircraft seats and lightweight armored vehicles. The DC slab casting process technology developed utilizes Elektron WE43, Elektron 43, and Elektron 675 to achieve high strength, and good flammability resistance and ballistic performance relative to aluminum alloys.

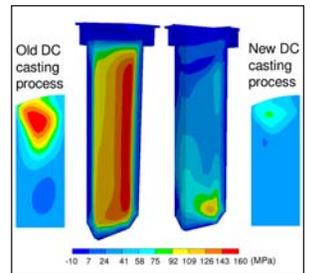


Aircraft seats (left) and armored vehicles (right) plan to use high-strength magnesium alloys, cast using newly-designed DC casting equipment and methodology. © Photos courtesy of Magnesium-Elektron UK. Used with permission.

Process development involved computer simulation to redesign DC casting process equipment and parameters unique to magnesium alloys. Previously, high-strength magnesium alloys were prone to cracking from residual stresses caused by large thermal

gradients generated during the DC casting process. Finite Element Method (FEM) computer simulation modeling allowed DC casting equipment to be redesigned, drastically reducing development time to produce cast slab product. Computer simulation software ALSIM predicts fluid flow, heat flow, solidification, stress and strain history within the magnesium slab.

Thermal flow validation was achieved by inserting thermocouples into the melt during casting, measuring and mapping out residual stresses in an industrial scale DC cast slab. Simulation modeling reduces cost and development time via virtual DC casting. The validated computer model achieves optimized casting parameters to produce crack-free magnesium slab. The redesigned DC casting equipment and parameters enable a large-scale, higher yield production route for Magnesium-Elektron to develop high-strength and ultra-high-strength magnesium alloy plate and sheet products using high-strength alloys such as Elektron WE43, Elektron 43, and Elektron 675 for a range of aviation/aerospace and military applications.



Crack-free DC cast Elektron™ 43 slab (top), and predicted residual stress fields within the slab cross section during DC casting (bottom). © Photo and graphic courtesy of Magnesium-Elektron UK. Used with permission.

City Bus Handrails Benefit from Rugged Attributes of Magnesium

The IMA Award of Excellence winner for Application is the Beijing Guangling Jinghua Science & Technology Co., Ltd., Beijing, China, for the magnesium alloy handrail for city buses. Key attributes of the AZ31B magnesium alloy that make it ideal for the handrails are light weight, shock absorption, vibration/noise dampening, and cost efficiency.



The curved, extruded magnesium tubing forms handrails that are lighter, thinner and stronger than aluminum handrails. © Photos courtesy of Beijing Guangling Jinghua Science & Technology Co., Ltd. Used with permission.

Utilizing magnesium alloy for bus handrails saves nearly 40 percent in weight. In a single city bus, total handrail weight adds up to 24.48 kilograms (kg), compared to 40.9kg for the same handrails made of aluminum alloy 6063-T5. The magnesium handrail component's thickness is 2.5mm, compared to 3.0mm for aluminum, and exhibits greater tensile and yield strength than its aluminum counterpart.

Key city bus producers in China, including the Yutong, Zhongtong, Ankai, and Foton bus companies are using the magnesium handrails, which are the proprietary innovation of the Gonleer Company. Lightweight AZ31B magnesium alloy helps reduce bus weight and noise, and improves shock absorption and rider comfort.

Lightweighting (reducing overall vehicle weight) by installing 2.35 million magnesium handrail units in thousands of Chinese passenger buses saves energy, reducing the buses' environmental footprints with the added benefit of being operationally more cost effective compared to other materials. After two years of testing, the magnesium handrails are in full commercial production, and are anticipated to expand their use in the transportation sector.

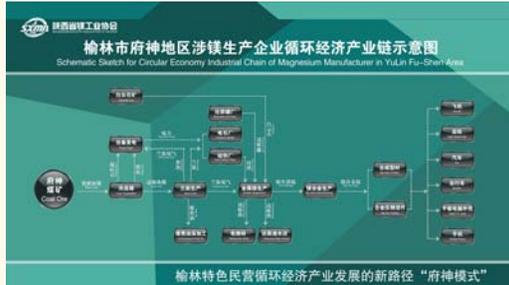


Thousands of magnesium alloy handrails are installed in Chinese Yutong city buses. © Photos courtesy of Beijing Guangling Jinghua Science & Technology Co., Ltd. Used with permission.

A Closer Look: 2012 Environmental Responsibility Award Winner

Fugu Magnesium Producers Increase Energy Efficiency and Reduce Emissions

Shaanxi Magnesium Association (SXMA), the thirty-three primary magnesium producers of Fugu County in Sha'anxi Province, China, received the IMA 2012 Environmental Responsibility Award for their collective efforts to recover and recycle semi-coke gas from semi-coke production as fuel for primary magnesium production, thereby reducing greenhouse gas emissions occurring during magnesium production. The Fugu area is located in Yulin, Sha'anxi, and is ranked as China's top energy producer, rich in coal, natural gas, petroleum, and halite resources.



Cyclic chain of Magnesium industry in Fugu, Sha'anxi, China. © Graphic courtesy of Fugu Magnesium Association and Magnesium Industry Association of Shaanxi. Used with permission.

cement, building material, and coal tar, forming a comprehensive utilization of their ore resources. The cyclic economy strives for efficient resource usage: semi-coke is produced through raw coal; magnesium and electricity are produced via flue gas from the semi-coke process; ferrosilicon is produced from both electricity and semi-coke; primary magnesium uses reductant ferrosilicon; and both cement and baking-free brick utilize slag from smelting magnesium.

Sha'anxi province magnesium output was 253,000 tons in 2011, and through March 2012, Sha'anxi (SXSM) member companies contributed 63,400 tons of magnesium, representing 49.2 percent growth in production compared to 2011. The Fugu Magnesium Association asserts that semi-coke gas use and improvements to magnesium smelting production technology reduced coal use by approximately 1,200,000 tons in 2011 and reduced CO₂ gas emissions by 46.7 percent, compared to the traditional Pidgeon process.



The FUGU county magnesium facilities in Sha'anxi reached output of 230kt as of May 2011, representing 36.5 percent of China's total magnesium production. © Photos courtesy of Fugu Magnesium Association. Used with permission.

Using semi-coke gas to power Fugu county's primary magnesium production operations has led to substantial growth in the Fugu magnesium industry, with combined on-stream capacity in 2010 of 178.4kt or 27.2 percent of China's total production – an increase from six percent in 2005. This complete cyclic process, compared to coal-fueled practices, results in higher resource utilization and energy efficiency. The process has achieved less environmental pollution and a smaller carbon footprint, as well as lower operational costs and greater competitiveness.

IMA congratulates all Awards of Excellence and Environmental Responsibility Award Winners who are dedicating their efforts to magnesium process and product innovations, setting ever-higher standards for making more efficient and environmentally responsible operations. These award-winning companies have found ingenious ways to produce, process, design, and build the global magnesium industry. They are demonstrating what is possible, and inspiring others to achieve even greater goals with magnesium innovations.



To learn more about the benefits of designing products with magnesium, contact the **International Magnesium Association**
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