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CASTING AHEAD

Die-Cast Magnesium Gaining Favor as Weight, Strength Attributes Balance Cost

Die-cast magnesium automotive front end structures such as these help manufacturers reduce vehicle weight. (Photo Credit: Meridian Lightweight Technologies)

With the global vehicle fleet expected to grow 3.5 percent annually through this decade, suppliers of key components are already seeing an increase in demand for raw materials and finished parts, say industry experts.

At the same time, manufacturers continue to invest in technology and innovation to satisfy customer demands for features, performance and efficiency

while working to meet ever-increasing global fuel-economy standards.

Meeting those demands often means specifying the right materials that make up the thousands of parts integrated into new cars and trucks while never taking an eye off the bottom line.

A recent trend that addresses some of those demands can be seen in the

use of die-cast magnesium, a metal favored by manufacturers and parts suppliers for its light weight and strength, but sometimes overlooked in favor of the more traditional choices of aluminum and steel.

STRONG OUTLOOK

The outlook for die-cast magnesium parts is strong, says Todd Olson, first

vice president of the International Magnesium Association (IMA).

“Traditionally, the strikes against specifying die-cast magnesium were almost all related to price,” Olson says. “Over the past three years, the price of secondary magnesium has stabilized and even come down some, but what has gone up is the real value in light-weighting a vehicle.”

And lightweighting is directly related to improved fuel economy, automotive designers and engineers’ lodestone for many years.

Olson believes that even if Corporate Average Fuel Economy (CAFE) goals in the U.S. are relaxed under the Trump administration, the continual push for higher fuel-economy numbers is here to stay.

“The EPA’s target of 54.5 mpg by 2025 is a stretch goal,” Olson says. “Even if CAFE is pulled back to 48 mpg or so, automotive design will continue heading in the direction of greater fuel economy.”

And, he feels, vehicle lightweighting by greater use of die-cast magnesium parts plays a key role in realizing fuel-economy numbers that were unheard of just 10 years ago.

Over the past quarter century, the industry has made tremendous strides in vehicle fuel efficiency with electronics and innovative designs aimed at lightweighting.

According to a report produced by die-cast manufacturer Pace Industries of Fayetteville, Ark., vehicle lightweighting reflects significant shifts in design thinking and materials specification.

“Cars have been made lighter by a combination of downsizing, new designs (such as cab forward and front-wheel drive), and shifts to lighter materials,” the report notes. “The most striking material shifts have been from iron to high-strength steel (HSS), and from iron and steel to aluminum and plastics.”

“Finally, magnesium offers even greater potential to reduce weight by displacing steel, and additional incre-

mental savings by displacing aluminum and plastics from uses already taken over from iron and steel,” the report concludes.

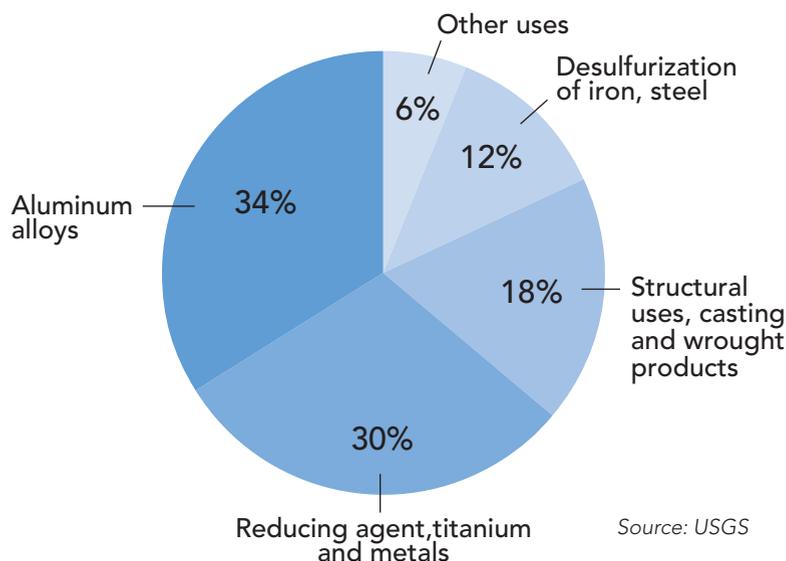
Companies such as Pace already are staking a place in the magnesium supply and parts production business.

A key factor in the bright future for magnesium is the global availability of ready sources that will ensure demand can be met for all the many uses of this versatile metal.

Magnesium Production & Reserves*			
	2014	2015	2016
Brazil	16	15	15
China	874	852	880
Israel	26	19	25
Kazakhstan	10	8	10
South Korea	10	10	10
Russia	50	60	60
Serbia	2	2	—
Ukraine	7	8	8
United States **	W	W	W
World total	970	974	1,008

Source: USGS
 * in thousand metric tons
 ** US production withheld; proprietary data

Magnesium Metal Demand, U.S.





Magnesium, shown here in crystalline form, is an abundant metal available around the world and can be produced from seawater, brines or mined and processed from mineral ores. (Photo Credit: CSIRO)



Magnesium ingots are loaded into die-cast machines at Meridian Lightweight Technologies. (Photo Credit: Meridian)

ABUNDANT ELEMENT

The eighth most abundant element in the world, magnesium makes up about 2 percent of the earth's crust and is the third most common dissolved element found in seawater, according to the U.S. Geological Survey (USGS).

Magnesium's symbol is Mg, and its atomic number is 12. It has a shiny gray appearance, similar to the other five elements in Group 2 on the periodic table, the alkaline earth metals. These are beryllium, calcium, strontium, barium and radium.

Magnesium occurs naturally only in combination with other elements and when burned, produces a characteristic brilliant-white light. This attribute is the reason magnesium was used in the early days of photography and in the first flashbulbs for illuminating a subject.

Magnesium metal can be produced from seawater and natural brines, and from dolomite and other minerals. Individual sources of magnesium "range from large to virtually unlimited and are globally widespread," according to the USGS annual summary.

About one-third of primary magnesium metal demand is as a reducing agent in the production of titanium and other metals. About another third is used in aluminum-based alloys for packaging, transportation and other products. Castings and wrought products make up about 18 percent. Approximately 12 percent goes into desulfurization of iron and steel. The remainder of domestic demand is for other uses.

The secondary magnesium market, sourced from recycled and scrap materials, is split roughly two-thirds

to aluminum alloys and one-third for structural uses, according to the USGS.

IMA's Olson, who is the chief financial officer at Twin City Die Castings of Minneapolis, notes that his company sources its entire supply of magnesium ingots from recyclers.

"With a single supplier of primary magnesium in the U.S. and tariffs applied to imports from China, we have several suppliers of recycled magnesium that compete for our business," he says. "We have found that secondary magnesium performs the same as primary."

PRODUCERS TO SUPPLIERS

US Magnesium of Salt Lake City claims the top spot among primary magnesium producers in North America and the only one operating in the U.S. Its production facility on the



Great Salt Lake has been producing magnesium since 1972. In that time, the company and its predecessors have invested more than \$120 million converting the original facility into a state-of-the-art plant.

US Magnesium's investments in electrolytic cells and gas-capturing equipment have allowed it to increase magnesium production by more than 30 percent while nearly eliminating chlorine and air emissions, and reducing power consumption by 25 percent, the company reports.

In addition to pure magnesium ingots, the company produces what it describes as high-purity, corrosion-resistant magnesium alloys for die and gravity casting.

Reporting on the secondary magnesium market, USGS states that of 91,000 tons of recycled magnesium

supplied in the U.S., 68 percent was recovered from aluminum-based alloys while most of the rest was recycled from magnesium castings, ingots and scrap.

Advanced Magnesium Alloys Corp., located in Anderson, Ind., is said to operate the largest magnesium-recycling facility in the world with an annual production capacity now at 50,000 metric tons. In 2016, the company restarted production equipment to doubled capacity.

The company's three secondary magnesium alloys—AM50A, AM60B and AZ91D—are all produced according to ASTM standards.

FAVORED METAL

Magnesium is favored by many designers, engineers and manufacturers for its strength-to-weight ratio, often cited as the best of any commonly used structural metal.

According to parts supplier Meridian Lightweight Technologies, magnesium can be die cast into single, thin-walled structures rather than assembled from several components. This simplifies designs, reduces machining and assembly costs, and requires fewer joints, fasteners and welds.

With its superior dampening capacity and low-mass inertia, magnesium is well suited for parts designed for frequent and sudden changes in motion direction, Meridian notes.

Headquartered in Plymouth, Mich., Meridian calls itself "the leader in innovative lightweight cast metal solutions for the transportation industry."

Magnesium is well suited for parts designed for frequent and sudden changes in motion direction: Meridian Lightweight Technologies report.

Parts designers favor die-cast magnesium over aluminum, Meridian says, for several of the metal's properties. These include parts that are 33-percent lighter with similar or superior mechanical characteristics, better machining qualities and longer machine-tool life, thin-wall castings that are more complex resulting in fewer components and less assembly, and generally better corrosion resistance.

When weighing material choices, the higher tooling costs of die-cast magnesium are offset by lower production costs, according to a report by Joe Petrillo, director of sales at Meridian. "Given that, die-casting magnesium becomes extremely cost effective."

"As long as the process can meet the product requirements, die casting becomes the method of choice," he added.

Magnesium die-cast parts are likewise favored over steel, the company says, as being 75-percent lighter, allowing improved fuel economy. Parts can also be produced that are more complex than steel without giving up strength.

As fuel-economy standards in many nations are pushed higher, "automobile manufacturers worldwide are turning



Example of a magnesium lift gate that is lighter and stronger (Photo Credit: Meridian)

to lightweight magnesium alloy parts as a way to reduce overall vehicle weight and improve fuel economy,” a report from Meridian says.

Seeking to expand the reach of its heavy manufacturing sector, Chinese companies have increased their ownership of raw materials production and parts manufacturing, according to international business analysis.

A report by Bloomberg in March indicated Chinese companies in 2016 invested a record \$1.6 billion in U.S. parts companies as they sought to gain access to the second largest auto market.

Meridian and its subsidiaries were acquired by Wanfeng Auto Holding Group of Xinchang in 2013. The move was intended to shore up the Chinese company’s ability to supply its North American customers, according to a company statement.

As it looks to acquire companies that have “strong research and profit-

generating capabilities,” Wanfeng also hopes to avoid customs issues and taxes that “can be highly variable and hard to predict,” according to Wanfeng Chairwoman Chen Ailian.

A bit further down the stream, Chicago White Metal Casting says its magnesium-casting operations can produce high-purity alloy parts that are corrosion resistant.

The company’s die-cast parts offer easy machinability, good thermal and electrical conductivity, thin-wall and complex parts applications, noise and vibration dampening, finishing and full recycling capability.

The company uses a hot-chamber process that has die-casting machines with between 200 and 650 tons of locking force to take advantage of the metal’s “excellent flow characteristics to accurately produce complex shapes.”

Another supplier is Spartan Light Metal Products of St. Louis, Mo. The

Research continues to improve materials processing technology. In Australia, a newly developed water-based replacement for chromate allows galvanizers to protect oxidation-prone metals such as magnesium from short-term corrosion without the use of hazardous solvents needed for chromate. (Photo Credit: CSRIO)

company states “when leading automotive manufacturers want lighter and more durable parts, they partner with Spartan to develop high-pressure die-cast products in light-weight metals.”

Spartan recommends magnesium as the material most suited for manufacturing the lightest and most durable die-cast products. “This alloy is 34% lighter than aluminum, 74% lighter than steel, and unlike plastics, is 100% recyclable. It also provides a longer tool life compared to aluminum.”

In some applications, magnesium has been substituted for aluminum with no change in total cost or loss of

performance, and realized weight savings of 35 to 50 percent.

MACHINE SAVINGS

Magnesium is also favored for its repeatability and better machine characteristics.

Die-cast molds are a significant part of a manufacturer's investment in a component or structural member.

With its less-abrasive characteristics, magnesium molds generally outperform those used in aluminum

die-casting, Twin City Die Castings' Olson notes.

"We find that magnesium molds last twice as long compared to aluminum," he says. "A mold is a considerable portion of a part's final cost. So, if you are replacing the mold after 100,000 impressions compared to 250,000 impressions for a magnesium alloy, the dollar savings are significant."

Pace Industries reports that casting and finishing magnesium parts can realize lower costs for the manufacturer.

"With the very low cutting pressure required, very close tolerances are achievable," reports Pace's Jim Hegland. "This low-cutting pressure also significantly lengthens the life of perishable tooling such as end mills, taps and drills."

"When you consider that magnesium die-cast tooling lasts two to three times longer than aluminum tooling, some tangible advantages start to develop," Hegland says. **LW**

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Issue of *Lightweighting World* OEM Focus!



Ford Motor Company's Lightweight Chassis Developments

Xiaoming Chen, John Uicker and their colleagues share two of the automaker's R&D efforts in lightweight chassis investigations, cast magnesium subframe development and carbon fiber composite subframe design.



Q&A with General Motors Lightweighting Experts

Learn how GM is utilizing advances in mixed materials and lightweighting strategies to improve vehicle performance and reduce CO₂ emissions. The result is that seven recent production models are lighter by an average 350 pounds compared with their immediate predecessors.

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