Charting a Course for Magnesium

Magnesium casting is in an enviable position to enter new and growing markets, but a course of action must be outlined to reach optimal growth.

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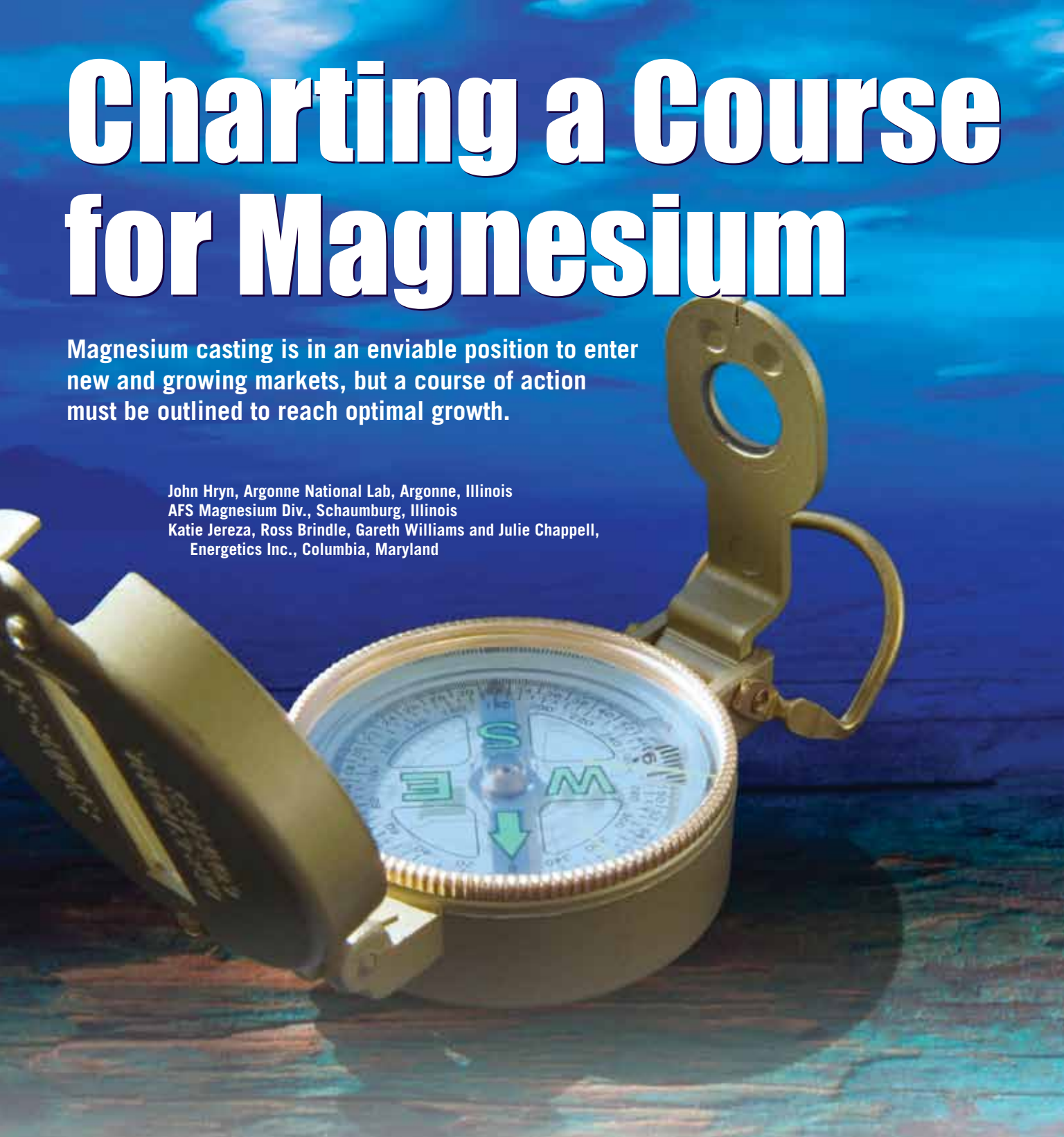

In 2004, the U.S. magnesium casting industry culminated ten years of remarkable growth by shipping nearly 100,000 tons of castings to a wide range of markets, including automotive, aerospace, power tools, sporting goods and electronic and computer products. This growth spurt came after four decades of yearly shipments totaling closer to 20,000 tons and is largely attributed to the use of magnesium diecast components in automobiles, which more than doubled between 1990 and 2000. During the last decade alone, growth in magnesium castings for light vehicles has averaged 16% per year and is predicted to grow at an annual rate of 11.5% for the next decade.

The lightest of all commonly used cast metal components, magnesium castings have a better strength-to-weight ratio than aluminum or steel. As such, the application of magnesium can reduce the total weight of an end-product, improve fuel economy, increase safety and handling, significantly lower emissions and increase recyclability. In addition, magnesium castings dampen noise and vibration, are highly impact- and dent- resistant, and are easily machined. The industry must maximize these inherent benefits in quality and design while maintaining affordability in order to survive and prosper in increasingly competitive and challenging times.

The next 15 years are critical for the magnesium casting industry, which must capitalize on an increasingly mobile, affluent and environmentally aware society. Tremendous technological advances have served to simultaneously raise consumer expectations of companies to offer better products and services and open large, new markets for lightweight components, clean transportation, and electromagnetic protection, which did not exist a decade ago.

Intense competition from cast parts made from different metals and materials also forces the magnesium casting industry to provide exceptional products and services at the lowest possible cost.

This transfer case for an SUV was sand cast with AZ91E magnesium with T6 heat treatment. The component measured 12 in. (30.5 cm) and weighed just 6 lbs. (2.7 kg).

Globalization, environmental issues and new technologies already have forced magnesium casting facilities to reevaluate their business strategies and identify new models for future success.

Strategic alliances forged between casting companies and research and development (R&D) facilities will help the industry provide innovative products and services, offer unique technology solutions, deliver superior value to customers, and set new standards of safety and environmental protection.

To facilitate this transformation, a technology roadmap for the magnesium casting industry has been developed by members of the AFS Magnesium Div. to chart a course for successful growth over the next 15 years. This roadmap outlines the strategic technology agenda for achieving the needs and expectations of customers, markets and society through three principal components:

- ***process technology***—Improving productivity, efficiency and operational environment while delivering consistent, high-quality castings at competitive costs has long been a pursuit of the industry. Developments that increase the range of cast geometries and properties and the enabling

Mapping the Route

A course has been charted for the magnesium casting industry to achieve its optimum capability using a timeline that has been divided into three different groups: near-term (0-5 yrs.), mid-term (5-8 yrs.) and long-term (more than 8 yrs.). Here are a few of the high-priority items for each term.

Near-Term (2005-2010)

- Develop and validate fluid flow and solidification models to improve prediction of casting properties
- Develop and implement melt protection technologies for molten metal handling
- Develop methods to affordably reuse in-house scrap without sacrificing quality.
- Develop a database of research and development projects, including previous, ongoing and future experiments, studies and other evaluations
- Develop an intermediate-scale research, development and demonstration facility with technical staff support
- Establish an industrial-based clearinghouse for alloy and process information and commercialization guidance

Mid-Term (2010-2013)

- Improve understanding of the effect of heat treatment on casting quality
- Develop affordable corrosion protection of components that maintain recyclability
- Develop a versatile casting machine capable of producing permanent mold, lost foam, precision sand and investment castings by means of pressurized filling (low pressure, counter-gravity, vacuum assist or electromagnetic systems)
- Develop an atlas of microstructures, casting defects and mechanical properties for typical magnesium casting alloys and processes
- Develop design and process guidelines for non-diecast magnesium metalcasting products
- Increase intermediate scale development and demonstration capabilities

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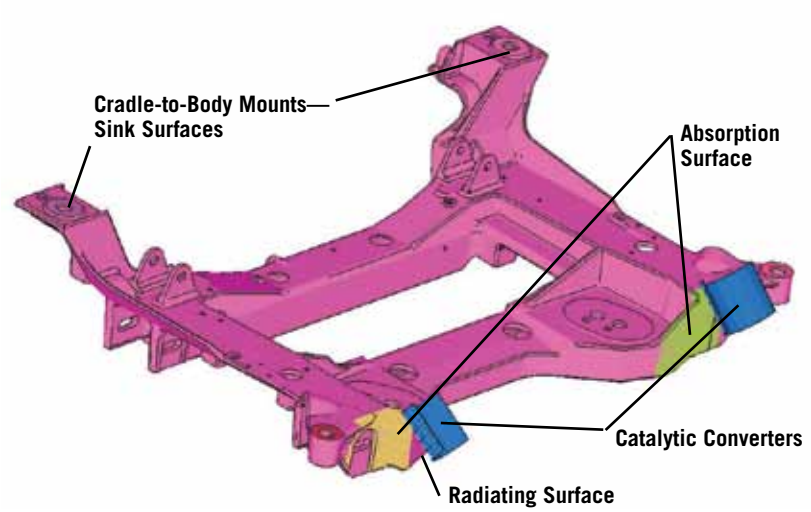


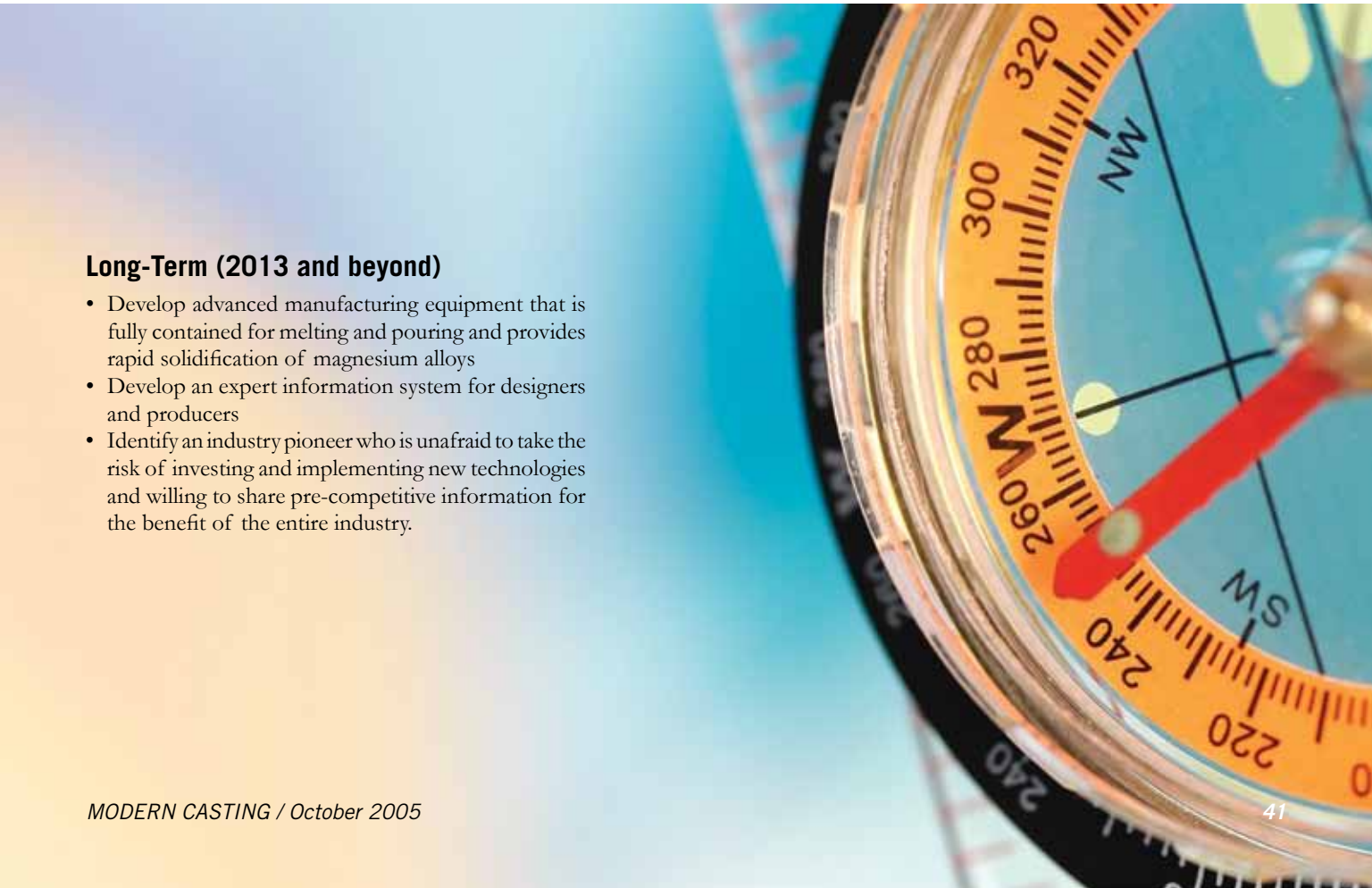
This casting process modeling image depicts a magnesium cradle for the Chevrolet C6 Corvette. Because points of the cradle are located near other engine units with high operating temperatures, a magnesium alloy that can withstand the heat intensity in the long term was needed.

technologies that support them are especially essential;

- ***information management and sharing***—Accelerated technological innovation requires information be shared and technology transferred within the industry and among the R&D community. This will facilitate adoption of developing technologies that attain market growth in the near term and provide a sustainable competitive advantage of the industry in the long term;
- ***infrastructure development***—The small size of the industry limits its ability to allocate major capital for unproven technologies, grow a network of auxiliary support or markedly increase its workforce. Infrastructure development must include mechanisms in manufacturing processes and casting techniques and increased involvement of auxiliary groups and potential employees to ensure the viability of the industry for years to come.

TOP PRIORITIES

The magnesium casting industry must pursue a balanced portfolio of research, development and demonstra-



Long-Term (2013 and beyond)

- Develop advanced manufacturing equipment that is fully contained for melting and pouring and provides rapid solidification of magnesium alloys
- Develop an expert information system for designers and producers
- Identify an industry pioneer who is unafraid to take the risk of investing and implementing new technologies and willing to share pre-competitive information for the benefit of the entire industry.

tion (RD&D), education, information management and other activities to support its efforts to promote industry growth. However, limited resources require the portfolio focus only on the most critical technology priorities to propel growth during the next 15 years.

The following six priorities illustrate how the magnesium industry can optimize production and increase use in new applications, especially through the expansion of industry capabilities and the collection and dissemination of information and resources.

Develop a Research Facility

The small size of the U.S. magnesium casting industry inhibits the uptake of new processes and technologies essential for magnesium casting producers to survive and grow in an increasingly competitive global marketplace.

An intermediate-scale RD&D facility will provide the means to evaluate new, potentially low-cost magnesium alloys, design several precompetitive components for the best alloy properties, cast and test the components in assembled products, and promote the use of improved magnesium alloys and casting processes.

Sharing information on previous, ongoing and future research and development (R&D) experiments, studies and other evaluations will help optimize and accelerate R&D efforts.

Expanding demonstrations of magnesium casting applications will enable the industry to determine technical issues, develop operating experience and expand awareness. The goal is to implement this RD&D facility by 2010.

Create a Database

Availability of information regarding magnesium research and development projects is critical to future industry success. Sharing information on previous, ongoing and future R&D experiments, studies and other evaluations will help optimize and accelerate R&D efforts.

The R&D database will document research activities related to magnesium casting, provide ready access to information about the latest developments in magnesium research, aid the planning of future research activities, avoid costly duplication of research and establish valuable contacts within the research community, government and the general public.

Funding opportunities for this database are to be identified in 2006, a philosophy of terms and protocols established in 2007 and previous data of experimental procedures collected in 2008.

Develop an Atlas of Properties

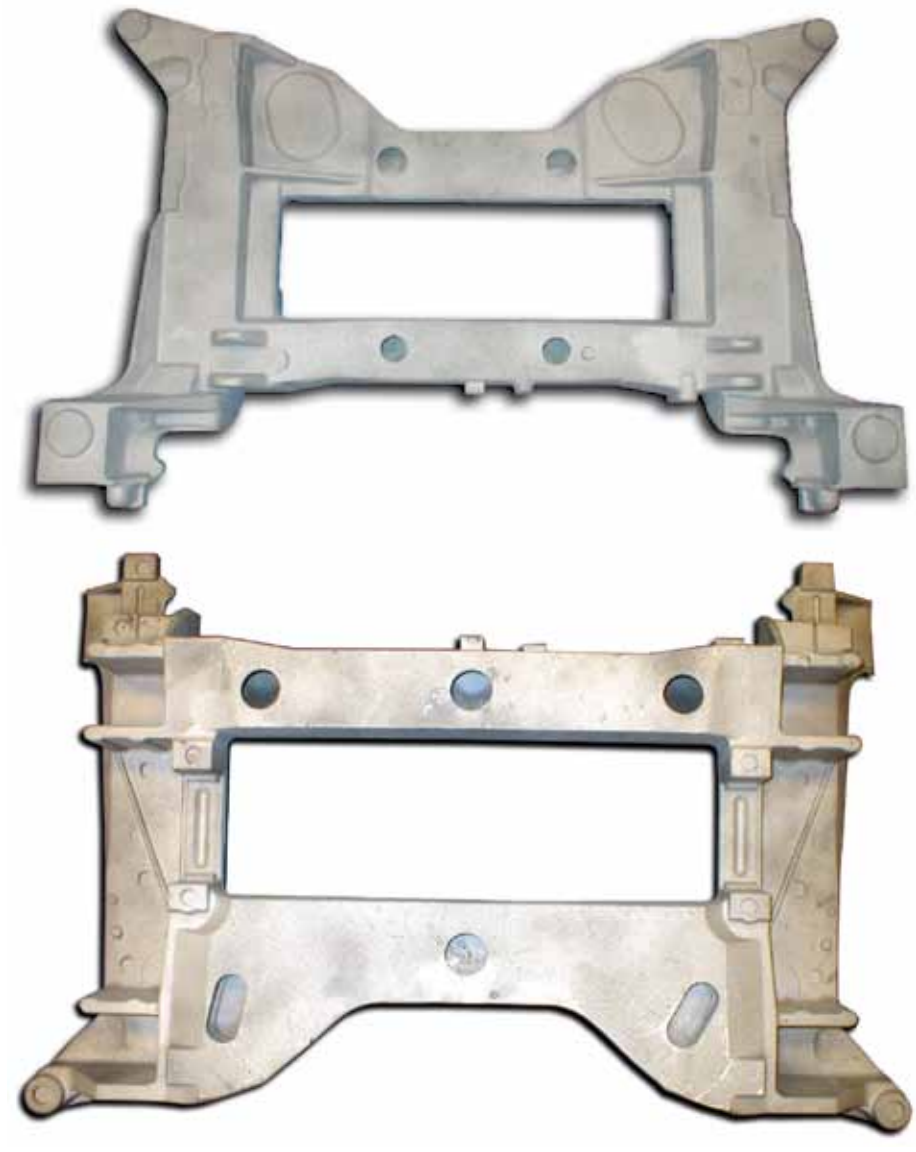
Microstructure, casting, defect and mechanical property data relevant to magnesium alloy selection are essential to determine optimal designs for each alloy to a performance specification.

Increased access to thermo and physical property data through an atlas of such properties will enable the industry to develop models, designs and processes with accurate, consistent data that will significantly shorten development and design times.

The action plan for creating this atlas of properties includes performing a literature review of existing data on microstructure casting defects and mechanical properties in 2006, gathering data by 2009 and achieving ASTM accreditation of casting defects by 2012.

Augment Melt Protection Technologies

Magnesium's reactivity and significant vapor pressure in the molten state requires the use of film-forming



These magnesium low-pressure permanent mold cradles, shown here, demonstrated better mold filling characteristics than expected with good fluidity.

inhibitors that limit metal losses due to oxidation and prevent oxide contamination of alloys prior to casting. For more than 20 years, the inhibitor of choice has been SF6, but new alternatives with both lower environmental impact and toxicity need to be identified.

Developing and implementing melt protection technologies for molten metal handling will increase the knowledge of current options, improve the consistency of data for comparison of current technologies, dramatically improve melt protection, reduce production costs and shorten leadtimes.

Existing technologies are currently being surveyed, validation studies will be performed in 2007, and new, cost-competitive procedures and materials will be developed by 2008.

Predict Casting Properties

Currently, existing models and thermo physical data do not accurately predict casting defects in magnesium alloys. Likewise, solidification expertise has not been communicated throughout the industry and has hampered property and defect prediction capabilities of magnesium castings. Although some fluid flow, solidification and heat treatment information is available, this knowledge is generally kept as trade secrets.

Development and validation of fluid flow and solidification models through improved computer-based modeling will reduce production costs, shorten leadtimes and increase yields.

Modeling software will be developed in 2006 using a team of software suppliers, universities, national labs and end-users. By 2008, the goal is to develop thermophysical property data and validate modeling by first casting simple geometries to confirm model predictions and then casting complex geometries.

Create a Casting Machine

A current lack of capability to produce consistent quality parts and the high price per product associated with magnesium hinders its entrance to new markets. The creation of a magnesium casting machine capable of producing permanent mold, lost foam, precision sand and investment castings by means of pressurized filling would provide the best quality castings, offer the best price/cost per product and increase market share to magnesium casting production.

Developing this casting machine will require close study of current best practices by process and material, determining the best package for casting magnesium, followed by design and construction of a preliminary RD&D machine by 2010.

The magnesium casting industry will continue to meet consumer expectations of product quality and services in lightweight component, clean transportation and many other markets while expanding its applications and abilities. This roadmap and its goals will help the industry reap the full potential of these opportunities and position it for remarkable growth in the years to come. ***MC***

Shipment Trends

As auto manufacturers continue to search for ways to reduce weight and meet Corporate Average Fuel Economy (CAFE) standards mandated by the U.S. Government, the magnesium casting industry is poised to further enter the automotive market through conversions from fabrications and weldments.

Manufacturers also will benefit from magnesium's ability to be cast closer to near-net-shape with thinner walls and better machinability, with an end result of lighter parts with better performance. The consumption of magnesium castings per light vehicle is forecast to triple by 2014, and applications of magnesium castings are expected to include increased use in instrument panels and brackets, steering column components, transmission cases, cylinder head covers, radiator support and intake manifolds. Future development will include control arms, steering knuckles and cradles.

Magnesium casting applications also will continue to grow in the aerospace, computer and electronics products, and sporting goods markets. Since the 1980s, magnesium castings have been used in stiffness-critical air frames and related drivetrain structures. Cast magnesium enclosures for electromagnetic shielding in computer and electronics products provide significant advantages in weight savings, raw material costs, structural strength, and durability over both plastic and alternative metal housings.

As manufacturers continue to demand components with reduced size, weight and cost along with increased recyclability and improved appearance, the magnesium industry will step up to meet these demands.

Finally, magnesium's ability to achieve tight tolerances, improved surface finishes, excellent dampening characteristics and weight reduction will continue to foster growth in the sporting goods market. ***MC***

Magnesium was the material of choice for this investment-cast telescopic trailer tow mirror mount for a pickup truck because of its superior metallurgical qualities and castability as well as its ability to provide a 3-lb. (1.36 kg) weight savings over aluminum.

For More Information

"Vacuum-Assisted Lost Foam Casting of Magnesium Alloy AZ91E," *Y. Fasoyinu, H. Chiorean, P. Newcombe and M. Sahoo, AFS Transactions (05-053).*