

## 2006 Abstracts

### **New Magnesium Diecasting Alloys for Decorative and Powertrain Applications**

*G. Dunlop, T. Abbott, M. Murray, C. Bettles, and M. Gibson, Advanced Magnesium Technologies (AMT)*  
AMT has recently launched two new magnesium diecasting alloys that address important issues for the future growth of magnesium markets. AM-lite is a new multi-purpose diecasting alloy with particular attributes for applications where high quality surface finishes are required. This alloy addresses many of the deficiencies of AZ91D. It also competes with zinc and aluminium diecasting alloys and plastics. The other alloy, AM-HP2, has been specially developed to provide a highly diecastable creep resistant alloy that is suitable for powertrain components such as engine blocks, structural sumps, engine covers and automatic transmission housings. AM-HP2 has similar diecastability to AZ91D and has a creep resistance that is similar to aluminium alloys commonly used in powertrain components.

### **The 3C Market – An Opportunity for Magnesium Injection Molding**

*Frank Czerwinski, Development Engineering, Husky Injection Molding Systems Ltd.*  
Among non-automotive applications of magnesium castings, the 3C market is emerging as the key player. The products cover computers, communications and consumer electronics including notebook PCs, mobile phones, mini-disc players, cameras and other handhold devices with yearly volume in the order of hundreds of millions of pieces and yearly growth for some of them exceeding 25%. A tendency of minimizing weight is important for complex-shape cases and frames, providing electromagnetic-interference shielding, heat dissipation and strength. Injection molding with its precise process control is well suited for manufacturing 3C components where wall thicknesses below 0.5 mm are frequently accompanied by long flow distances and requirements of outstanding surface quality, suitable for fashionable finishes. The paper describes technical aspects of manufacturing 3C components using magnesium injection molding. The conventional and novel processing routes, taking advantage of controlling the melt temperature and its flow into the mold, are analyzed along with requirements imposed on alloy properties both in the molten state and after solidification. Some directions for alloy development are defined. The processing details are accompanied by recent advances in hardware design, aimed to optimize injection parameters and alloy distribution systems (hot runners).

### **A Feasibility Study on Spot Friction Welding of Magnesium Alloy AZ31**

*Tsung-Yu Pan, Ford Motor Company; Mike Santella, Oak Ridge National Laboratory; P. K. Mallick, The University of Michigan – Dearborn*  
Spot friction welding (SFW) is a novel variant of the linear friction stir welding process with the potential to create strong joints between similar, as well as dissimilar sheet metals. It is particularly suitable for soft, low melting point metals such as aluminum, magnesium, and their alloys where resistance spot welding can cause defects such as voids, trapped gas and micro-cracks due to the intense heat requirement for joint formation. Up to now, spot friction welding has focused primarily on aluminum alloys. This paper presents a feasibility study on spot friction welding of AZ31, a wrought magnesium alloy available in sheet form. Lap joints of 1.58-mm-thick magnesium alloy AZ31B-O sheet were produced by spot friction welding. The spot welds were made in 2 sec with 15-mm-diameter pin tool rotating at 500-2,000 rpm. The tool was inserted into 2-sheet stack-ups to depths of either 2.4 or 2.8 mm relative to the top sheet surface. Tensile-shear testing showed that joint strengths up to 4.75 kN were obtained. The removal of surface oxides from the sheets prior to welding increased lap shear strengths about 50% at the 2.4-mm insertion depth and it promoted failure by nugget pull-out rather than by interface separation.

### **Heat Treatment of AZ91D Magnesium Vacuum Die Castings**

*Xiong Shoumei, Department of Mechanical Engineering, Tsinghua University, Beijing*

Conventional die castings are rarely possible to be heat treated because gas porosities come into blisters on component surface at a high temperature. Vacuum die casting process is usually considered capable to minimize gas porosities in die castings and makes heat treatment process possible to improve its microstructure and mechanical properties. In current research, experiments for AZ91D magnesium alloy were carried out using a property test die designed according to ASTM standards and on a 650T cold chamber die casting machine. Standard die casting specimens for property test were heat treated in T6 process. Mechanical properties and corresponding microstructures before and after heat treatment were investigated. The influence of vacuum level on the capability of vacuum die castings to be heat treated and the properties was studied. Based on experimental results, the minimum vacuum level for heat treating vacuum die casting components was indicated.

### **Research of Productive Process of Section Extrusion for AZ31 Magnesium Alloy**

*Yao Wendong, Xu Chunsen, Beijing GangLing Jinhua Science & Technology Co. Ltd*

The productive process of the section extrusion for AZ31 magnesium alloy has been researched on the productive line by device of horizontal extrusion. The best extrusion operation is designed for AZ31 magnesium alloy. For example: the temperature of the extrusion barrel, the temperature of Mg billets, the preheating temperature of the die, the extrusion speed and the technique of the designed die and the process by which fine crystal granularity can be obtained. The results show that the highest yield strength and tensile strength are obtained and the section extrusion has better plasticity, fine crystal granularity and glabrous surface by analysis of the microstructure and mechanical properties of the section extrusion.

### **New Magnesium Diecasting Alloys: Driving Development of Critical Automotive Applications**

*Hakon Westengen, Per Bakke and Jan Ivar Skar, Hydro Aluminium*

In recent years, a series of new critical applications of magnesium die castings for automotive use has emerged. These include crash sensitive parts, engine parts and load bearing suspension parts. A main driver behind these developments is the availability of new alloys particularly developed for specific applications. Furthermore, die casting equipment suppliers and suppliers of enabling technologies have contributed by developing magnesium specific solutions to the technical challenges encountered. The presentation focuses on recent accomplishments and points towards further technical challenges.

### **Magnesium Product Stewardship**

*Tom Tripp, US Magnesium LLC*

Magnesium metal is a versatile material with a considerable number of technical and environmental advantages. These advantages have yielded a trend of economic growth. At times these obvious advantages seem diminished in the general public's perception by news media reports of sensational, biased (and sometimes even spurious) magnesium incidents. Further growth of the magnesium industry depends in part on the public and government regulators perceptions of and cooperation with industry. The presentation will focus on the magnesium industry's need to develop to good product stewardship. Both suppliers of magnesium metal and magnesium consuming customers must become partners in promoting magnesium use, magnesium safety, and environmental responsibility. The benefits of educating public policy makers, news reporters and emergency responders towards preserving the growth magnesium will be discussed. Magnesium environmental issues and safety topics may also be discussed in this context

### **Development of Non-SF6 and Structural Control Techniques for High Performance Magnesium Alloy Project of Japan**

*Tomokazu Yamashita and Kazunori Shimizu (SANKYO ALUMINUM INDUSTRY CO., LTD.), Akihiko Ikegaya, Nozomu Kawabe and Yukihiro Oishi (SUMITOMO ELECTRIC INDUSTRIES, LTD.) Ken Saito and Tadayoshi Tsukeda (THE JAPAN STEEL WORKS, LTD.) Sachihiko Isogawa, Toshio Suzuki and Masashi Sakata (DAIDO STEEL CO., LTD.)*

SF6, which is used as a magnesium protection gas, is a high greenhouse effect gas whose emissions must be reduced. In Japan, in order to solve this subject, the "Development of Non-SF6 and Structural control Techniques for High Performance Magnesium Alloy Project" cooperate with four companies has been started in 2004. The aim of this project is to develop the technology of melting, refining and semi-continuous casting with a grain refining for a magnesium alloy without SF6 on a mass-production scale. And the obtained magnesium alloys are used through the newly developed metal working processes to improve the mechanical properties which are equivalent to that of aluminum alloys.

### **The modification of Pidgeon process Mg smelting mechanical equipment and technology and the deep-processing of magnesium alloy**

*Xu Yue Wang, Shanxi Wenxi Yinguang Magnesium Industry Co. LTD*

This article talks about Pidgeon process method of producing magnesium alteration, according to long years of practical experience of China Shanxi Wenxi Yinguang Magnesium Industry Co., LTD. Pidgeon process method of producing magnesium has the problem that the processing equipment drop behind the times ,and of the low efficiency , large consumption of natural and energy resources , severe environmental pollution etc. We realized comprehensive production process mechanization and automatization by equipment and technique improvement, and pollution abatement in the production . Basically ,we've realized the good effect of economizing on energy , lowering expend, environmental protection by Pidgeon process method. Meanwhile, our company developed many new techniques to produce magnesium alloy products and built up several product lines for die casting, rolling and extrusion. Remarkable effect has been obtained in using energy with high efficiency.

### **Magnesium alloys and corrosion protection techniques currently studied in IMR**

*Enhou Han, Rongshi Chen, Dayong Shan, Lu. Liu and Wei Ke, Institute of Metal Research, Chinese Academy of Sciences*

This paper will present a abundant of research results on magnesium alloys in 6 topics in terms of both fundamental and application researches; the topics include development of a new low-cost cast Mg-Al-Zn base alloy, development of a wrought Mg-Zn-Y-Zr alloy, mechanical properties of Mg-Li base alloys, creep resistance of Mg-Y-Nd-Zr alloys and its plastic processing ability, fatigue and environmental fatigue behaviors of both Mg-Zn-Y-Zr and extruded AM60 magnesium alloys. Corrosion protection techniques of AZ31 and AZ91 magnesium alloys, such as phosphate conversion coating, nickel plating coating and anodization coating, will also be presented.

### **China Magnesium Industry Development Report for 2005**

*Mr. Meng Shukun, Mr. Wu Xiuming, Mrs. Han Wei, Mr. Dong Chunming, China Magnesium Association*

This article releases the output, exports and domestic consumption of primary magnesium and of magnesium alloys in 2005 in China. The economic operation situation of Chinese magnesium industry in 2005 is analyzed as an emphasis, which characterizes increasing production but with milder and less speed than before. The unit resource consumption is being reduced and the smelting scale is being expanded and downstream processing industry is being changed into more highly added value products. In 2005, the domestic consumption overtakes 100,000 tons, as lowers the dependence degree on exports. The exporting product structure is being optimized and environmental pollution are within controls and improved. At last, this article pointed out the existing profound paradoxes in the Chinese magnesium industry, including some major urgent problems and solutions.

### **Dedicated Die Concepts for Worldwide supply of Magnesium Parts**

*Andreas Mueller, Georg Fischer GmbH & Co KG*

To use slides in the die to exceed shape needs is the common way to overcome this problems.

Georg Fischer, Altenmarkt is using a special die concept to produce brackets for steering columns.

Original used in the plastic molding this technology was developed by GF only for casting requirements.

Now this concept is used for Mg and Al with high efficiency world wide. In this paper the concept of the dies and development and production of the parts will be presented.

### **Structural Strength of Permanganate Conversion Coatings on AZ91D Mg Alloy**

*Fang-Chun Liao, Da-Yeh University*

In this study, AZ91D magnesium alloy is selected as the experimental material. Meanwhile, permanganate conversion coatings, which are widely used for surface treatment in industries, are adapted to have fundamental discussions. The operating parameters studied including solution temperatures and immersion times, also using OM, SEM and XRD to examine the surface morphology, growing structure and analyze the chemical composition of coatings, which obeys to determine the growth mechanism. Also, using adhesives to do the adhesion test and obtain the shear strength between coatings and base material directly. According to these data, we can correlate the relations between conversion coatings structure and shear strength.

### **Investigation on Magnesium Rare Earth Master-Alloys**

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A series of magnesium-rare earth master alloys have been developed by the electrowinning method with subsidence cathode. Experimental results showed that the optimum for electrolyte at 850°C and 10~20wt% RECl<sub>3</sub> content in the molten salt system. The component of master-alloys was analyzed using ICP-MS and chemical method. A series of magnesium-rare earth master-alloy, Mg-Y, Mg-Nd, Mg-Ce, Mg-La, Mg-Nd-rich and Mg-LPC were successfully prepared and the content of rare earth is adjustable between 5 ~ 20%. The applications of rare earth magnesium alloys in China were also reviewed.

### **A Study on Clean Magnesium Production with Pidgeon's Process**

*He Xu, WINCA Materials Technology (Beijing) Co., LTD.; Shuisheng Xie, Beijing General Research Institute for Non-Ferrous Metals; Dehong Xia, Dept. of Thermal Eng., Univ. of Science and Technology Beijing*

The technological development of the Pidgeon's process has pushed the cost of magnesium down to a historical low and the magnesium produced by the Pidgeon's process has dominated the world market. Though many factories have continued to increase their focus on controlling them, low thermal efficiency and loss of emissions are still two major issues impacting the future development of the Pidgeon's process. This paper compares the pollution produced by the Pidgeon's process with that of the electrolysis method, discusses several effective measures for saving energy and reducing pollution that are being applied to the Pidgeon's process and presents an array of effective methodology, currently being utilized in the field. It has been discovered that the thermal efficiency of Pidgeon's process can be increased about 2/3

### **Automotive Mg in North America**

*Joseph A. Carpenter, Jr., Office of FreedomCAR and Vehicle Technologies, U.S. Department of Energy; Jennifer Jackman, CANMET- Materials Technology Laboratory, Natural Resources of Canada; Naiyi Li, Ford Motor Company; Richard J. Osborne and Bob R. Powell, General Motors Corporation; Philip Sklad, Oak Ridge National Laboratory*

Expanding world economic prosperity and the probable peaking of conventional petroleum production capacity in the coming decades requires efforts to increase the efficiency of the use of and to develop alternatives to, petroleum-based fuels used in automotive transportation. North America has been aggressively pursuing both approaches for over ten years. Mainly as result of lower prices for primary

metal by China and Russia, magnesium has recently emerged as a serious candidate for lightweighting and thus increasing the fuel efficiency of, automotive transportation vehicles. Automotive vehicles produced in North America currently use more Mg than vehicles produced elsewhere in the world, but the amounts per vehicle are very small in comparison to other materials such as steel, aluminum and plastics. The reasons, besides price, are primarily a less-developed state of technology for Mg in automotive transportation applications and lack of familiarity by the vehicle manufacturers with the material. This paper reviews past, present and future North American activities in Mg for automotive applications.

### **Magnesium in Automobiles – Application Trends and Advantages**

*Glen Simonds and Brian Su, Meridian Technologies Inc.*

Increasing occupant protection and safety requirements and a proliferation of on-board electronics is increasing the weight of each new generation of vehicles. At the same time governments are legislating reductions in CO<sub>2</sub> emissions and fuel consumption. To offset the impact of increasing weight on the vehicle emissions OEM's need to implement light weight materials and technologies that will also meet the increasing safety performance requirements. This paper will look at some of the light weight Structural Magnesium Applications that are currently in production, the advantages they offer the customer and their design trends. It also looks at some of the recent and upcoming future applications where magnesium may be used to further reduce vehicle weights and increase fuel economy, handling and performance.

### **Cold Chamber Casting Unit for the Safety Casting “Bearing Block” and Hot Chamber Casting Cell for Gear Housing**

*Dr.-Ing. Norbert Erhard and Roland Fink, Oskar Frech GmbH & Co. KG*

Automotive Applications – The production of a bearing block, which integrates the function of a braking and coupling bearing, in automotive applications. The bearing block is a safety part. In the area of the bearing shrink holes may not occur. The part weights 1.4 kg. The wall-thickness is between 2.5 and 8 mm. The presentation includes the filling and solidification simulation. The die design shows the necessary ventilation. The bearing block is cast on a cold chamber machine with 11000 kN locking force. Casting parameters, casting graphs and quality tolerances as well as quality monitoring is presented with respect to the complete casting cell.

Non-Automotive Applications - Computer and Cell Phone – With this universal carrier eighteen types of cell phones can be connected. The casting is very complicated. 25 openings are used for holding the parts necessary for mounting. The casting can be mounted directly after casting and surface treatment without any reworking. The angle tolerances are  $\pm 0.1^\circ$ . The alloy is AZ 91 HD. The diecasting die has two cavities (shot weight 301 g) and is cast on a hot chamber diecasting machine with 3150 kN locking force. The presentation includes the simulation of the filling and solidification processes, the conception of the diecasting die and the casting parameters as well as the process control of the total, fully-automatic casting cell.

### **Magnesium Supply and Demand – 2005**

*Mr. Nick Fantetti, Dead Sea Magnesium*

This paper presents the situation of the world market in the year 2005. Analyses are based on statistics prepared and published by the International Magnesium Association (IMA) covering mainly: Deliveries of primary magnesium for the different end use segments and by geographical zones, and Production in the western world, in the CIS and in China. The IMA figures account only for primary magnesium demand and shipments only and ignore remelting and recycling. Evolution of magnesium consumption in each end use segment is commented. The situation in the US is addressed in light of the particular developments that occurred in that market during the course of 2005. The evolution of magnesium production and internal consumption in China and how these two items affect the balance are addressed. Other key factors influencing the balance of demand and supply as well as the areas of applications offering potential growth opportunities in the future are discussed.