2009 Abstracts

China Magnesium Industry Updates in 2008

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In 2008, basically speaking, the China's magnesium industry develops well, with the primary magnesium output of 558 k metric tons, 396.4 kt exported and 158 kt consumed inside. The sales for the whole industry rises by 56% year on year, with net profit up by 41% and exports income up by 62% compared to last year. However, since Sept. 2008, due to slipping prices and the financial crisis, which affects a lot the confidence of investors and consumers to the China's magnesium industry, many smelters have to cut down or cease their production. The stringent situation continues when it enters the year 2009.

Eco-Mg for Magnesium Future

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The environmental benefits provided by lightweight, unlimited, and recyclable Mg alloy have the potential to grow significantly in the future if the global Mg industry is working together to demonstrate its stewardship by eliminating global warming SF6 or other protective gases as well as Be addition not only for environment and toxicity issues but also for the synergy of cast shop infrastructure with Al industry and by ensuring safety during manufacturing and application, especially without sacrificing process abilities and mechanical properties or increasing the cost of Mg alloy. This is what Eco-Mg (Environment conscious magnesium) is all about.

The simple and plain approach of Eco-Mg is to introduce low-cost CaO of below 0.3wt% as ingredient into conventional cast and wrought Mg alloys for (1) non-SF6 processing, (2) Be elimination, (3) improved melt cleanliness, (4) ensured original process abilities for casting, forming, joining as well as surface treatment, (5) improved mechanical properties by grain refinement and internal soundness, (6) ensured safety during manufacturing and application by raising oxidation and ignition resistances, (7) improved recyclability, and (8) cost reduction.

CaO can be introduced as alloying element for developing low-cost special Mg alloys such as high-temperature, non-inflammable, damping, bio-degradable, desulfurizing Mg alloys without decreasing the property of purpose when compared with generally developed Mg alloys.

Development and Processing of High Temperature Magnesium Alloys

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Development directions of creep resistant magnesium alloys, starting from conventional Mg-Al-RE (AE grades) and Mg-Al-Si (AS grades) to other systems, involving rare-earth and alkali elements, are summarized. The considerable effort, which has been devoted over last decades, aimed at identifying alloying elements with a lower cost and a better effect on improving creep, is also discussed. The processing challenges during manufacturing various components are considered with implications for high-temperature properties and a tendency to form certain defects. A particular attention is paid to recent development of new methods of netshape forming, including semisolid-

state routes operating at a wide range of solid/liquid ratio. For complex alloys, containing volatile elements, the reduced processing temperature provides benefit to stability of phase and chemical composition. At the same time, however, it causes essential changes in phase composition at the stage of forming, imposing challenges on unique chemistry requirements, possibly different than designed for conventional casting.

A COMPARISON OF THE BALLISTIC PERFORMANCE BETWEEN ROLLED PLATE IN AZ31B-H24 MAGNESIUM & 5083-H131 ALUMINUM

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The U.S. Army Research Laboratory (ARL) and Magnesium Elektron North America (MENA) have conducted a joint effort to develop and evaluate rolled plate in commercially available magnesium alloy-temper AZ31B-H24 [1]. MENA produced the rolled product and conducted the mechanical analysis, while ARL performed the ballistic analysis. The magnesium alloy plates were parametrically compared with the minimum performance requirements of aluminum alloy 5083-H131 temper rolled plate using various armor piercing and fragment-simulating projectiles (FSP). The ballistic results and comparisons are presented herein.

ANALYSIS OF STRESS EVOLUTION IN HIGH TEMPERATURE CREEP TESTING OF CREEP-RESISTANT MAGNESIUM ALLOYS

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The main focus of this study was characterization of stress evolution in magnesium alloys developed for high-temperature applications. Several alloying groups have been analyzed representing Mg-Al-Rare Earth (RE), Mg-Al-Sr, Mg-Al-Ca, and Mg-Zn-Rare Earth systems. The samples were cast in permanent mould and extruded, and then subjected to 200 hrs of creep under load of 50 MPa for duration of 200 hours at the temperatures of 150oC and 175oC. Primary and secondary creep evolution was observed for the studied alloys under both tensile and compressive creep load. In-situ and creep-induced intergranular residual stresses, as well as crystallographic texture, were analyzed with application of neutron diffraction techniques at the Canadian Neutron Beam Centre in Chalk River, Ontario. The in-situ diffraction pattern shows the consecutive responses of the crystallographic lattice to the sample heating, creep loading, unloading, and cooling. Correlation of the resultant elongation of the sample (creep) to residual stress and crystallographic texture has also been demonstrated for several crystallographic planes. The study provides a valuable insight on the material response to the high temperature creep.

Die Casting for the Future Economically and Ecologically

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The magnesium die casting is a production process which is used for many years for the serial production of different products. The technology used for that has been developed considerably further in the last years. Today the die casting process is a production process with a high grade of automation. Following the state of the art is explained, to describe with it the room for improvement with regard to environment, energy consumption and safety in the process guidance. The described technology allows new procedures so that efficiency and productivity of the die casting process increase.

Results are shown by means of some examples, especially in the application of high-grade and thin-walled magnesium die casting.

The Implications of the Euro Union REACH Initiative
Jo M.A. Willekens, IMA European Representative
(PowerPoint Presentation)

- The EC takes environmental and human health issues serious
  - CO2 emission reductions
  - Recycling regulations
  - EC crash requirements

- And there is also REACH

MagForming - Development of New Magnesium Forming Technologies for the Aeronautics Industry
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MagForming is a three year research and development program funded by the European Union under Framework Six Priority 4 Aeronautics and Aerospace. The aim of the work is to advance the state of the art in forming methods for a range magnesium alloys in extruded, sheet and plate forms using aerospace prototypes as demonstrators. The project is a collaboration between 12 different partners including material manufacturers, tier 1 aerospace suppliers and end users, as well as a number of academic institutes**.**

The program is split into a series of work packages, each targeting a specific area of forming. This includes forging, superplastic forming, roll bending, pad forming, deep drawing, and creep forming. The project aims to develop best practices for all of these methods via the production of aerospace prototype parts. This not only acts to demonstrate the forming process and its application to magnesium alloys, but also results in the production of useful parts for testing, potentially leading to the use of magnesium in the system and structure areas from which the parts have been taken.

Each application is reviewed with a detailed account of the development of the forming process. This is supported by analysis of the resulting component.

Surface Treatment of Cast AZ91 Alloy
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Cast AZ91 is the most typical magnesium alloy due to its superior combination of castability, mechanical strength and ductility. However, it also suffers from poor wear and corrosion resistance, which limits its wider industrial applications. Surface treatment has been recognised as a major emerging technology that can solve this problem without significantly changing the microstructure and properties of the substrate at relatively low cost. The present work reports the most recent results of four most effective approaches to the surface modification of AZ91 alloy. They are surface

nanocrystallization through surface mechanical attrition treatment (SMAT), surface alloying with Al, kinetic metallization coatings and anodizing treatment. The treatment processes will be described and the wear resistance, corrosion resistance and microstructure analysis will be discussed in the present paper.

One Pass Large Draught Rolling of Magnesium Alloy Sheet near Room Temperature by High Speed Rolling

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AZ31B and AZ80A magnesium alloy sheets are rolled up to 60% reduction in one pass rolling below 200 °C at the rolling speed of 1000m/min and 2000 m/min without heating rolls. The enhanced ductility in high speed rolling results from temperature rise due to plastic work. During rolling of a sheet, heat is generated by plastic deformation and by friction between the material and rolls. Meanwhile the heat transfers from the material to cold rolls. With increasing the rolling speed, the duration where the material and the rolls are in contact becomes shorter. This results in effective temperature rise of the sheet during
rolling. So fracture or cracks due to the low-temperature brittleness can be suppressed considerably by high-speed rolling. The rolled and quenched sheets showed fully recrystallized microstructure at higher reduction. The microstructure was homogeneous throughout the thickness. The finest recrystallized grain size was 2.2 μm for AZ31.

The Automotive Process Chain for Forming Magnesium Parts

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The importance of weight is becoming ever greater in today's automotive industry. Whilst preserving vital performance factors, the employment of lighter building materials can significantly reduce the weight of a vehicle. Newer research projects focus on the material magnesium and its applications as a substitute for conventional sheet metals.

Clearly, production of fine magnesium sheet can only commence once it is established that a large part of the steps in the production line, including the successive stages of blanking, punching and hemming, can be carried out using unheated or only partially heated tools.

At *utg,* the forming process of a passenger car inner convertible roof could be adapted to magnesium using a heated deep drawing tool. Ongoing research focuses on the reduction of energy consumption of the forming processes. This is achieved by locally heating the active tool elements where necessary. As the fabrication of stiffening corrugations represents a relatively small stress for the material, it is more an application for cold or mildly heated tools. Blanking of magnesium sheet with locally heated active elements is also implemented prototypically at utg. Based on the results, an innovative tool concept was developed implementing blanking with selectively heated tools. The hemming of the same sheet quality has also been tested using selectively heated tools.

Using Mg to Reduce Weight in Automotive Power-Train Applications

By: Glen Simonds C. Eng.. Meridian Lightweight Technologies Inc.

It is becoming increasingly difficult for automotive engineers to deliver the customers expectations of comfort, performance and safety and at the same time meet the tougher CO^2 emission regulations being implemented globally.

Other than power substitution such as hybrid power, electric power or hydrogen fuel cells, the alternative for the internal combustion engine is to achieve higher fuel efficiency. This can be achieved by improved engine control systems or by reducing the driving resistance. And one way to achieve that is to reduce the weight of the vehicle. The average vehicle sold in 2007 weighed 483 lbs more than in 1997 and nearly half a ton more than in 1987 6

There is a wide variety of data on the correlation between weight reduction and fuel economy savings. With a 10% weight reduction the % of fuel consumption reduction is reported to be between 5% and 8% [1]. Reducing the weight of a vehicle will reduce the amount of fuel consumed and therefore the amount of CO^2 emitted.

One area where significant weight reduction opportunities exist is in the power-train components and die cast *Magnesium* can help achieve this weight reduction.

Development of light and cost effective roof bracket
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An innovative light roof bracket made of die cast magnesium AM60 alloy was developed by "ORTAL DIE CASTING". This product will replace an existing bracket produced with inserted components of sintered steel teeth rack into the magnesium roof bracket, and affixed by plastic deformation process. Innovative and accurate die casting technology made it possible to integrate the teeth rack as part of the roof bracket. Via that technology the cost of the product will dramatically reduced. Preliminary results of functional tests, hardness, wear resistance and mechanical strength were obtained to ensure reliability and endurance of the new integrated die cast magnesium teeth rack. Simulations, mechanical and functional tests were also obtained from experiments that were carried out on machined parts with different casting parameters. Metallurgical evaluation of the microstructure was obtained by optic and electrons scanning microscopy.

AEROMAG - Magnesium suitable for aeronautic applications?
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AEROMAG – Aeronautical Application of Wrought Magnesium, a three years research project, was funded by the European Commission under FP6. The aim of the 20 project partners from suppliers, universities and aeronautic industry was to evaluate if Magnesium products with a density of only 65% of aluminum, could be a break through technology for the aerospace industry if used for aircraft components.

The technical focus of the project was the investigation of new Magnesium wrought products (sheets and extrusions), that provide significantly improved static and fatigue strength properties, which were required to be as high as typical 5xxx and 2xxx aluminum alloys.

It was shown that besides hot forming also welding technologies like LBW and FSW are working well. Corrosion was solved with environmentally friendly surface protection systems and advanced design concepts. Flammability was addressed with the chemical composition and special surface treatments. Finally, material adapted design and the evaluation of structural behavior was investigated and concluded with a cost/weight evaluation for aeronautic components.

Development of Magnesium Alloy Parts for Airbus Aircrafts
Matthias Knüwer, Alexandra Guillan, Patricia Besuchet, Heinz-Peter Busch, Wolfgang Entelmann(Airbus);Elke Hombergsmeier (EADS Innovation Works)
Magnesium alloys had been widely used in aircrafts up to the 1950s. Due to some major drawbacks such as high corrosion sensitivity and, under extreme conditions, flammability other materials, both metals and plastics, have increasingly replaced magnesium. Airbus is now reappraising the introduction of magnesium alloys in aircraft based on the results of recent research projects. This paper shows the latest results together with some promising applications for different alloys and product forms. Furthermore Airbus is developing and investigating approaches for a lab scale fire testing procedure with the scope to ensure compliance with FAA-regulations on aircraft fire safety.

Safe Clean and Efficient solutions for Energy Storage
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(PowerPoint Presentation)