International Magnesium Association

"The premier conference for all magnesium industry leaders."

23-27 August 2021

78th Annual IMA World Magnesium Virtual Conference 2021

Conference Agenda

Monday, 23 August 2021

07:00 – 07:05

Welcome & Sponsor Remarks

MAGNESIUM TRAINING 101

07:05 – 07:25 **Mg Overview & Applications**
Alan Luo, The Ohio State University

Description: This talk provides an overview of historical and current magnesium applications as the lightest structural metal compared with other major materials. The presentation will also discuss future applications of magnesium as a structural and functional material.

07:25 – 07:50 **Cast Mg Alloys & Processes**
Jonathan Weiler, Meridian

Description: The two largest uses of primary magnesium are as alloying additions for aluminum alloys and for magnesium alloy casting processes. These processes include sand casting, permanent mold casting, thixomolding and die casting, among others, producing components for the automotive industry as well as other growing markets. A wide range of magnesium alloys are used in these processes, depending upon the application, working environment, and ease of processing. In this session, we will cover an introduction to the primary casting methods using magnesium alloys. We will also cover the various magnesium alloys used in these casting methods, their properties, benefits, and limitations.

Finally, a review of key applications utilizing these magnesium alloy casting processes will be summarized.

07:50 – 08:00 Break

08:00 – 08:25 **Wrought Mg Alloys & Processes**
Scott Sutton, Mag Specialties

Description: This talk will give a high-level overview of wrought magnesium alloys and processes. General properties of wrought magnesium will be reviewed, and wrought process basics and commercial applications will be discussed, with a focus on considerations for magnesium alloys.

08:25 – 08:50 **Mg Product Design & Development**
David Klaumunzer, Volkswagen

Description: In a wide range of applications to date, Magnesium has proven to be a durable and reliable material, e.g., for automotive castings. To ensure full functionality of lightweight components, material-specific design considerations must be taken into account. Examples of recent case studies will highlight the important steps in magnesium product design and development.

08:50 – 09:05 **Mg Safety & Handling**
Helmut Poell, RAUCH Furnace Technology GmbH

Description: This magnesium safety and handling presentation will focus on Mg hazards, especially in the molten state, suggested personal protection equipment (PPE), basic safety precautions and safe work principles, and fire protection and extinguishing.

09:05 – 09:30 **All Presenter Q&A**

Tuesday, 24 August 2021

07:00 – 07:05 Welcome & Sponsor Remarks

SESSION 1: MARKET

07:05 – 07:30 **Global Primary Mg Production Supply Demand 2020**
Alan Clark, CM Group

Description: In a year like no other, the trajectory of global commodity markets was smashed by the COVID-19 pandemic. Their unexpectedly rapid rebound has been influenced strongly by specific geographies and key market sectors. The global primary Mg market has been no exception. This paper presents an overview of the 2020 global primary Mg supply demand balance, as well as outlining current trends in China's primary magnesium production base. The paper also presents an overview of the potential impact of China's 14th Five-Year Plan on primary magnesium production, including its

decarbonization policies. The paper finishes by addressing the issue of rising aluminum prices and the potential for die casters to substitute magnesium as a result, as well as providing an update on new global primary production capacity and the potential impact on global markets.

07:30 – 07:40 ***Health & Safety Award Presentation***

07:40 – 08:05 **Automotive Materials in an Electrified World: Understanding Aluminum's and Magnesium's Role in Lightweighting**
Abey Abraham, Ducker

Description: Outlining the fact-base and industry snapshot, comparing and contrasting the NA light vehicle market and its shift towards electrification; Implications on materials (share of aluminum and magnesium today) and outlook; Outlining why/how magnesium and aluminum work well together (beyond for alloying needs); Drivers and barriers for continued growth of lightweight materials (addressing the question: if battery costs achieve less than $100/KWH, is lightweighting still considered?); Comparing and contrasting aluminum cast content in ICE vs. BEV—what is added vs. what is removed and what is the net effect; How materials selection is done at the OEM—compromise with cost, performance, etc.

08:05 – 08:15 ***Automotive Cast Product Award Presentation***

08:15 – 08:25 Break

SESSION 2: AUTOMOTIVE APPLICATIONS

08:25 – 08:45 **Lightweighting Trends Using Magnesium in Recent Vehicle Launches**
Jon Weiler, Meridian

Description: Magnesium has been proven to be an important material for lightweighting potential in automotive applications. Numerous applications have proven to provide significant mass reduction, as well as part consolidation, in the case of die-cast components. Magnesium is important for both internal combustion engine vehicles and electric vehicle architectures for vehicle mass reduction, providing fuel economy improvements for ICE vehicles and driving range improvements for EVs. This paper summarizes magnesium applications in several key recent vehicle launches and their challenges and solutions through innovations in design, joining technologies, and corrosion mitigation solutions.

08:45 – 09:05 **Concepts for a Seat Backrest Structure Using Extruded Magnesium Profiles**
Sebastian P. Sikora and Elmar Beeh, German Aerospace Center (DLR e.V.)

Description: In large-scale production of vehicle seat structures, high and ultra-high strength steel alloys prevail because of challenging requirements, mainly concerning passenger safety. The project FUMAS (Functionally integrated magnesium lightweighting for automobile seat structures) aimed at weight reduction by using extruded magnesium (an alloy of the type MgMnCe) and novel process routes in

manufacturing. Concepts for a lighter seat back structure have been developed, dimensioned, and evaluated. The underlying predevelopment process is based on numerical as well as experimental methods at different levels coupon, generic component, and demonstrator level. Good-natured, ductile failure behavior has been observed using rectangular closed profiles in bending at high testing speeds, which makes the use of the alloy promising for seat applications. The proposed backrest structure builds on a three-part magnesium frame assembly that is joined to so-called mobile steel gussets at the transition to the seat area. Two alternative structural concepts have been developed utilizing different joining technologies — friction stir welding and injection adhesive bonding.

09:05 – 09:25 **VW Manual Gearbox 5 Speed: Development of New Lighter Gearbox Housings in Magnesium**
Osvaldo Vicentin, RIMA Industrial and Volkswagen do Brasil

Description: Volkswagen do Brasil (VWB) has been using magnesium housing in gearboxes for many decades due to local magnesium competitiveness advantages compared to aluminum in both cost and lightweight characteristics. Recently, in developing a new VW vehicle platform, we had to change the engine mounting design, which required a new screw with higher class (10.9 instead of 8.8). This higher class would require a longer depth of the thread in the gearbox and clutch housings. As a project premise to keep totally interchangeable designs of the gearbox housings in both aluminum and magnesium (a VWB decision for its lightweight designs), the engineering team had to figure out a technical solution to fulfill the lower hardness that AZ91 has compared to AlSi9Cu3 alloys. These challenges motivated our team to develop some pioneering solutions in terms of die-casting design and machining processes by introducing aluminum inserts in AZ91 magnesium die-casting parts in some critical areas of the final products. This paper will briefly describe the ideas and concepts used to develop this unique solution for the replacement of castings parts originally born as Aluminum products to Magnesium casting parts, including the die-casting design with inserts, injection, and machining process steps. This hard work has involved teams with different skills working together in 3 different countries as Brazil, Germany, and Czech Republic and the VW magnesium gearbox housings will start serial large-scale production this year in South America.

09:25 – 09:30 Closing Remarks

Wednesday, 25 August 2021

07:00 – 07:05 Welcome & Sponsor Remarks

SESSION 3: NEW APPLICATIONS

07:05 – 07:25 **Activities of Japan Magnesium Association and Progress of Applications in Japan**
Daisuke Konishi and Kazumasa Yamazaki, JMA

Description: Activities of JMA, current status of magnesium industries and progress of applications in Japan are reported. JMA continues to hold many seminars to enhance its activities. Committees on high-speed railway vehicles and automobiles continue. The casting committee, which was established with the investment of member companies for the purpose of determining easy-to-recycle alloys, is also producing results. Committees on batteries that were established last year have met regularly to create battery performance evaluation standards. A new committee was established regarding a method for extracting magnesium at low cost from the concentrated seawater generated in the process of producing freshwater.

07:25 – 07:45 **Advanced Alloying Anode for Magnesium-Air Batteries**
Shanghai Wei, The University of Auckland

Description: Magnesium-Air (Mg-air) batteries have been receiving much attention in recent years. Due to high theoretical energy density, low cost, and environmental-friendliness, they have been considered as a promising electrochemical energy storage technology for future energy demand. The theoretical voltage of a Mg-air battery is 3.1 V and the theoretical specific energy density is 6.8 kWh/kg. However, Mg-air batteries are facing a number of challenges, including high self-corrosion and low anodic efficiency. In the present research, hypoeutectic Mg alloys have been designed and fabricated for improving the discharging performance. Microstructure and phase composition of alloys before and after battery discharge testing have been characterised by OM, XRD, SEM, TEM and STEM techniques. The electrochemical properties of these Mg alloys have been analyzed using a three-electrode electrochemical workstation.

07:45 – 08:05 **Boosting Performance of Primary Aqueous Mg Batteries from Anode and Electrolyte Sides**
Mikhail Zheludkevich, Helmholtz-Zentrum Geesthacht

Description: Aqueous primary Mg-based batteries are a promising alternative to conventional energy storage devices, thanks to negative electrode potential and high volumetric capacity of metallic Mg. However, several critical factors decrease the efficiency of Mg batteries and limit their wider application — namely the self-corrosion of anodes and electrode blockage by the discharge products. In this work, the discharge properties of Mg-based batteries were boosted through optimization of Mg-based anodes via Ca addition and designing the new electrolyte additives. It has been shown that the optimized Mg-Ca anode confers higher cell voltage and higher specific energy density than a high purity Mg and several commercial Mg alloys. The enhancement of Mg-based batteries' performance can also be achieved by adding organic additives into electrolyte, which can prevent the formation of insoluble precipitate on the electrode and accelerate the dissolution of magnesium anode. Therefore, it can increase the cell voltage and specific energy of Mg-Ca system battery.

08:05 – 08:15 ***Commercial Cast Product Award Presentation***

08:15 – 08:25 Break

SESSION 4: COATING & JOINING

08:25 – 08:45 **Dissimilar Material Joining of Thixomolded Magnesium Alloy**
Takeshi Yamaguchi, The Japan Steel Works, Ltd.

Description: Advanced multi-material concept is efficiency to design optimization and potential weight reduction of automobiles. Especially, composite structure parts consisting of the three major light materials (plastics, aluminum alloy, magnesium alloy) is a high priority for automobile body lightweighting. Conventional approaches of dissimilar materials joining for composite structure leads to limits on shape and efficiency. Thus, the majority of recent developments in dissimilar material joining have been driven by the requirement of higher productivity and lower cost. In this report, injection molding was used for dissimilar material joining. Injection molding is an effective mass-production process for creating highly complex parts. First, laser surface pre-treatment is applied for thixomolded magnesium alloy and over-molded fiber reinforced plastics by injection molding. Then we developed innovative hybrid bonding of magnesium alloy and other metals such as aluminum alloy through the thixomolding process. Tensile strength and interface microstructure of joining these dissimilar materials were examined.

08:45 – 09:05 **Development of Plating Process Suitable for Various Magnesium Alloys**
Msafumi Nozak, Okuno Chemical Industries

Description: Zinc substitution and electroless Ni-P plating are used as a protective layer in the method of electroplating on magnesium alloys. However, these methods have some problems which increase the number of treatment steps, and plating adhesion may not be obtainable, depending on the kinds of magnesium alloys. We investigated the composition of pretreatment solution, and the composition and treatment condition of an electroless Ni-P plating bath. We succeeded in obtaining the plating film with excellent adhesion to various magnesium alloys(AZ-91, LZ-91, AZ-31, AM-60, ZK-60A and Mg-Gd magnesium alloy). Furthermore, it was possible with fewer treatment steps than the conventional method. We discuss the plating process on magnesium alloys, film properties, and deposition mechanism in this report.

09:05 – 09:10 Closing Remarks

09:10 – 09:35 Networking Session

Thursday, 26 August 2021

07:00 – 07:05 Welcome & Sponsor Remarks

07:05 – 07:35 **IMA Member Meeting**

SESSION 5: PRIMARY PROCESSING DEVELOPMENT

07:35 – 07:55 **Systematic Energy Saving and Low Carbon Technologies for Pidgeon Process Improvement**
Dehong Xia, University of Science and Technology Beijing

Description: Creating clean, efficient, and low-carbon production processes represents the key to achieve the new standard of CO2 emission control. Mg production in China accounts for over 85% of the world, and more than 90% of the Mg is extracted by the Pidgeon process. However, lower energy efficiency, heavy pollution, and intensive CO2 emission hindered the sustainable development of the magnesium industry. To address these problems, a novel high-efficiency Pidgeon process for magnesium production — characterized by clean production, higher energy efficiency, and resourceful utilization of CO2 — are proposed in this report, including: a new dolomite calcination technology with CO2 looping and recovery; an efficient vacuum reduction furnace with low NOx regenerative combustion, an advanced waste heat recovery technology of high-temperature calcinated dolomite and reduction slag, and a re-utilization process of Mg reduced slag.

07:55 – 08:15 **Techno-Economics and Life Cycle Analysis for a Carbothermal Reduction Process to Produce Primary Magnesium Metal**
Boris Chubukov and Dr. Aaron Palumbo, Big Blue Technologies

Description: The carbothermal reduction process for primary magnesium production has the potential to be near net-zero in emissions while being economically competitive with Chinese Pidgeon on production cost. A variation of the CTR process was recently implemented in Denver, Colorado, USA, using a 50 kW electric arc furnace for reduction, a high temperature heat exchanger for condensation, and in-situ vacuum distillation for purification and recovery. Total energy consumed was estimated at 12 – 20 kWh/kgMg, where the major opportunity for heat recovery is from combustion of the byproduct carbon monoxide gas. Depending on the ore source (brucite vs. magnesite), primary fuel source of electricity (renewables vs. coal-fired power plant), and the carbon source (biochar vs petcoke), total ore-to-ingot emissions were estimated at 0.5-12 kgCO2/kgMg. Estimated plant operational costs ranged from $1,400 – 2,100/t-Mg and initial capital expenses ranged from $4,500 - $5,500 per ton-capacity, depending on the size of the plant.

08:15 – 08:25 ***Wrought Product Award Presentation***

08:25 – 08:30 Break

SESSION 6: ALLOY DEVELOPMENT

08:30 – 08:50 **New Generation Magnesium Based Multicomponent Alloys: Processing and Properties**
Khin Sandar Tun and Manoj Gupta, National University of Singapore

Description: Available soon.

08:50 – 9:10 **Advancements in Low-Flammable Mg-CaO Alloy Systems Processed by Two Environmentally Friend Processes: Hot Extrusion of No-Remelt Recycling Chips and Inert Gas-Assisted High Pressure Die Casting**
Fabrizio D'Errico, Politecnico di Milano

Description: Available soon.

09:10 – 9:30 **Excellent Formability and Age-Hardenability of Non-flammable Mg-Al-Zn-Y-Ca Alloy Sheet**
Sangbong Yi, Helmholtz-Zentrum Geesthacht

Description: The alloying of rare earth elements or Ca is well acknowledged to improve the room temperature stretch formability of Mg alloy sheets to be comparable to that of 6000 series Al alloys. Moreover, the simultaneous addition of Ca with Y results in an excellent ignition-proof behavior and improved corrosion resistance. This study extensively examined the relationship between thermomechanical treatments and the resulting properties of the non-flammable Mg-Al-Zn sheet alloys modified by Ca and Y addition, with focus on clarifying the influence of Al content on microstructure evolution and mechanical properties. The stretch formability at room temperature could be significantly improved, e.g. Erichsen index of 8.5, by controlling the process parameters during the rolling. Besides, the non-flammable alloy sheets with bake-hardenability were achieved by reducing the Al content and accompanying control of dissolved alloying elements in the matrix.

09:30 – 09:35 Closing Remarks

Friday, 27 August 2021

07:00 – 07:05 Welcome & Sponsor Remarks

SESSION 7: PROCESS DEVELOPMENT I

07:05 – 07:25 **Trend Towards Larger Die Casting Machines**
Tom Rookus, Buhler

Description: Structural components have clearly gained importance in the automotive industry in recent years or even decades. This trend has accelerated rapidly in the past 2 years with not only a push toward larger structural components, but also an increased desire to die cast 5G parts, automotive panels, and large battery housings for electric vehicles out of both aluminum and magnesium. This creates further opportunities for the die-casting industry, some with high volume potential. This development is clearly reflected in the demand for ever-larger machines. Various die-casting machine manufacturers already have solutions for this — in the clamping force range of 5,000 to 9,000 tons. This demand will likely continue in the long term, as shown, for example, in the front and rear structure presented by Tesla on

Battery Day 2020, but also in the discussion about producing more truck parts using the die-casting process. However, the newly developed die casting machines are only a first step — there are many other points to consider when increasing production. In addition to the machine, critical points are the height of the hall, including crane loads, the handling of the molds, internal logistics of the parts, and finally, the transport to the customer. The question arises whether such large parts are increasingly being cast by OEMs themselves, ideally near the final assembly of the vehicles.

07:25 – 07:45 **Semi-Solid Metal Injection Molding—The Future of Lightweight Metal Parts**
Edo Meyer, MAXImolding! Technology GmbH

Description: Thixomolding is a very complex process and highly maintenance-intensive. We wish to improve it by replacement of barrel and extruder with a high thermal mass cylinder revolver. The Canadian Team of MAXImolding invented and patented a new vertically oriented, environmentally friendly Semi-Solid Metal Alloy Injection Molding Machine. We dedicated all our working life to solve these problems: production of high-integrity net-shape light metal parts, reducing porosities in molding parts, and doing it with zero emissions. We are fully committed to improving the current non-sustainable approach of molding, inspecting, separating, and re-melting. The MAXImolding processing parameters are optimized without a human operator by closing a real-time X-ray feedback control loop based on the parts, quality indicators, and proper AI algorithms. This is an intrinsically safe, energy and material efficient, environmentally sound magnesium-molding self-learning smart factory with no emissions outside of factory parameters limits.

07:45 – 08:05 **Magnesium Alloy Wire and Wire Arc Additive Manufacturing (WAAM)**
Chunjie Xu, Xi'an University of Technology

Description: This topic introduces the research orientation, direction, and progress of Xi'an Schechtman Nobel Prize New Materials Institute. The research of high-end magnesium alloy materials, as well as the application of magnesium alloy in automobile and other fields, are introduced. According to the research field of the Institute, the preparation process of 1 mm diameter magnesium alloy and magnesium matrix composite wire materials is mainly analyzed, as well as the magnesium alloy additive manufacturing process using WAAM technology. In addition, the microstructure and properties of magnesium alloy samples manufactured by SLM are briefly introduced.

08:05 – 08:15 ***Process Award Presentation***

08:15 – 08:25 Break

SESSION 8: PROCESS DEVELOPMENT II

08:25 – 08:45 **Improving the Mechanical Properties of Magnesium Alloys through Differential Speed Rolling**
Zhigang Xu, NC A&T

Description: Magnesium (Mg) alloys have great potential to be used as structural materials in the automotive and aerospace industries. Due to its HCP crystallographic structure and a limited number of slip systems, the wrought Mg alloys exhibit poor formability at room temperature. Differential speed rolling (DSR) is an effective method to enhance their formability by applying a shear strain to the plates during rolling, which will lead to a tilted basal texture towards the rolling direction, as well as a refined microstructure through enhanced dynamic recrystallization. In this investigation, the effect of the speed ratio, rolling temperature, and thickness reduction on the evolution of the microstructure and mechanical properties of the rolled MgAl alloy plates were studied in comparison to conventional rolling (CR). Results show that DSR had an obvious advantage in refining the microstructure, weakening the basal texture, and consequently improving the strength and ductility over CR.

08:45 – 09:05 **High-Strength Mg-Al-Ca Alloys for Wrought Applications**
Stefan Gneiger, AIT Austrian Institute of Technology

Description: Low density and high specific stiffness make Mg alloys particularly suitable for transportation applications. Advantageous properties such as low melting point, low heat capacity, and good machinability have earned Mg alloys acceptance as castings in certain high-volume applications like gearbox housings and electronics casings. However, for forming processes such as extrusion and forging, Mg alloys currently find little to no industrial use. One reason is often their low strength compared to competing materials such as Al alloys and high-strength steels. Also, rare earths are frequently used for generating high-strength Mg alloys, which often raises questions of economics and availability. Here we show that high yield strength (greater than 300 MPa) can be achieved in the Mg-Al-Ca system while maintaining good ductility, using only low-cost elements. Our investigations show that these properties can be achieved over a wide alloy composition range, greatly simplifying both processing and recyclability.

09:05 – 09:25 **Close-Die Forging of LZ/LAZ Materials for Digital X-ray Detector**
Ching-Tang Chang, AMLi Materials Technology Co., Ltd.

Description: Magnesium-Lithium alloy, LZ and LAZ with density 1.48g/cm3 and 1.52g/cm3, respectively, have excellent formability and EMI properties. These major superiorities can apply to many types of medical equipment — especially the digital X-ray detector. Using the base-plate and back cover of 14"x17" digital X-ray detector, compared with aluminum alloy, the case weight of LZ/LAZ alloy can be almost reduced by half, and the whole detector is less than 2.5kg. This lightweight detector is much easier for operator manipulation. Moreover, the excellent EMI property, keeping X-ray scattering inside the case, can increase 40% raw data intensity and induce 25% image quality improvements. These characteristics can really help medical professionals with image diagnostics — especially coronavirus symptoms.

09:25 – 09:30 Closing Remarks