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A Perspective: Why Magnesium?

Stephen Brown - Meridian Lightweight Technologies UK Ltd.

Abstract

Meridian Lightweight Technologies UK (MLTUK) are part of Meridian Technologies Inc., which is part of the Wanfeng Auto Holding Group. MLTUK are the leading full service supplier of innovative lightweight Magnesium die cast components and assemblies in the global automotive market.

MLTUK was set up in 1999 and have a passion for Magnesium - regularly campaigning for industry and engineers to have a better understanding of Magnesium to allow it to take its rightful place alongside other less suitable structural materials in use today.

MLTUK is working in partnership with Birmingham City University (BCU) to improve industry understanding and assist in increasing the opportunities across the industry spectrum. Academics at BCU will provide Meridian and industry with a greater scope of application ideas.

Why Magnesium? Magnesium, designed and optimised in the correct manner, will provide an enhanced strength, stiffness and stability, and will deliver a higher specific yield strength and specific modulus than nearly all other structural metals.

Magnesium is readily available, as it is the 8th most abundant natural metal. Its excellent strength/stiffness to weight ratio surpasses most other natural metals, allowing it to be a metal of choice when looking for a very light (up to 50% lighter than aluminium), stiff, energy efficient and recyclable natural material for our modern day design needs.

Our partnership is committed to improving the industry understanding of Magnesium and will encourage the automotive industry to improve. The industry is increasing its use of Magnesium yearly and our partnership intends to lead the industry, which presently lacks the skills and expertise regarding the do and don'ts necessary when designing and developing in Magnesium. These judgements can lead to ill-advised dangerous decisions being made during the design stages. Misconceptions are still rife at OEM Engineering level. MLTUK are committed to tackling this issue wherever we can, and in the most professional manner, in partnership with BCU.

Want to understand more about the potential of Magnesium for your business?
Register free for Birmingham City University's Magnesium Symposium on 20th July.

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A Perspective: Towards improvement of the formability of magnesium alloys

Michal Krzyzanowski[1], Krzysztof Muszka[2], Marta Slezak[2] and David Randman[3]

Abstract

It is the lowest density of any structural metals that makes magnesium and its alloys to be very attractive materials for a wide range of structural applications, especially where weight saving is of paramount significance, such as in automotive or aerospace industries. Despite the attractiveness as a lightweight structural metal, the use of traditional Mg alloys is limited mainly due to its poor formability, corrosion resistance, and a limited strength capacity at elevated temperatures. The forming of magnesium alloys is still difficult, and its plastic deformation mechanisms are not yet clarified. Alternative slip systems, other than basal slip, have to be activated during the deformation process of Mg-alloys to extend its utility. Therefore, twinning, as another deformation mechanism, can play an important role in coordinating the plastic deformation. Experimental investigations have revealed that texture plays a significant role in improving or impairing the ductility of Mg-alloys. The activated deformation modes highly depend on the orientations of the grains, in such way depend on the texture, the deformation path and the mechanical process. The combined effect of grain boundary strengthening, second phase strengthening and activation of non-basal slip mechanisms may lead the way to better Mg-alloys, which will have both decent ductility and impressive strength.

The application of magnesium alloys requires reliable simulation tools for predicting the forming capabilities, the structural response to mechanical loads and the lifetime of the component. The respective constitutive models have to take into account the peculiarities of the mechanical behaviour assuming yielding under multi-axial stress states. A reliable numerical model of strain hardening, which is going to be developed in the project, will give an explanation and a prediction of both stress-strain curves and texture evolution. Recently developed method combining accumulative angular drawing (AAD) with wire drawing is used as a testing method to effectively induce severe plastic deformation (SPD) effects into the drawn metallic material. The influence of the combined effects, such as area reduction, bending, shearing and burnishing, on the accumulated deformation energy and microstructural inhomogeneity in the h.c.p. wires is discussed with respect to possibilities of formation of ultrafine-grained and multi-layered structures in subsequently drawn wires. The basic idea of AAD process is deformation of the metallic material tomuch higherplastic strains compared to the conventional wire drawinginducingvery high grain refinement allowing for achievement ofsignificantly higher tensile strength and ductility. It can be especially beneficial for Mg alloys.

The dynamic material modelling (DMM) approach is presented and demonstrated as a useful tool to predict workability of Mg alloys. The approach is based upon the fundamental principles of the continuum mechanics of large plastic flow, the physical system modelling and irreversible thermodynamics. In DMM approach, an efficiency of power dissipation between heat and microstructural changes is assumed to bea measure of workability of metals.

Based on the above assumption, the processing maps (P-maps) are constructed as an explicit representation of the material response in terms of the microstructural mechanisms and the applied process parameters. P-mapsare prepared by means of the combination of the power dissipation map, illustrated by isoclines, with the instability map, plotted in the frame of the temperature and the strain rate at a constant strain. The variations of the instability parameter, as a function of the strain rate and the temperature,allow for plottingthe instability maps. The regions on the map, where the instability parameter is lower than zero, correspond to the microstructural instabilities in the material. This parameter is considered to be an important warning sign for designing aneffective metal forming operation for a specific material.

High-temperature rheological research is modern research, allowing for obtaining the key information on the influence of forces and the time of their impact on a specific material. Such information is essential for designing of the forming processes in semi-solid states. A comprehensive and accurate description of the rheological behaviour seems to be a key factor for development and optimisation ofsemi-solid forming of Mg alloys. Rheological testing of Mg alloys is challenging due to the high reactivity of the materials.The results of the recent rheological testing of AZ91, WE43B and E21 Mg alloyswith different chemical compositions are discussed. The findings are presented in the form of flow curves. The preliminary results indicated that the highest shear stresses,around of 50Pa, were obtained for AZ91 alloy, while only the stresses within the range of 10 – 20Pa have been registered for E21 and WE43B alloys. Both E21 and WE43B alloys contain rare earth elements, such as yttrium, neodymium, gadolinium, which may influence the changes in the shear stress. Further rheological testing of the materials with various contents of the rare earth metals are planned to verify the above mentioned statement.In addition, a tendency towards non-linear growth of the shear stress with the growth of the strain rate is noticed that may indicate decline in the dynamic viscosity coefficient, as a result of the applied load.

For more insights on Magnesium sign up for our Magnesium Symposium on 20th July.

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A Perspective: Magnesium in the Automotive and Aerospace Industries

Abed Alaswad – Lecturer, School of Engineering and the Built Environment, Birmingham City University

Abstract

Driven by the climate change issue, and the global response to it, a significant effort has been spent, over the last few decades, on the lightweight industry as it has been proven to lead to a less fuel consumption, less pollution, along with better drivability and performance. In this regard, Magnesium is considered to have an excellent potential as it is one of the lightest structural metals offering great weight saving. However, due to a number of technical and commercial obstacles, Magnesium has not been promoted effectively on a wide scale. Therefore, a good deal of research is needed to overcome these barriers, aiming towards bigger involvement of Magnesium in Automotive and Aerospace industries.

In this research, the viability of using Magnesium alloys in structural components in automotive industry is investigated by exploring the crashworthiness behaviour for different metals under different loading conditions. The effect of thickness increase on the absorbed energy and the material weight will be covered. A proposal on how to effectively measure crashworthiness for Magnesium and how to improve its behaviour in energy absorption is described.

Gain access to further research on this subject and more by signing up for the Magnesium Symposium on 20th July.

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Attitudes on Magnesium Alloys

Panagiotis Rentzelas and Eirini Mavritsaki – School of Social Sciences

Abstract

Magnesium based alloys are versatile products that can have a lot of innovative applications to the automotive and aerospace industry. However, it seems that there is not empirical and systematic research on the engineer's attitudes towards the use of magnesium alloys especially in these industries. In this line of research we try to address this gap in the literature by employing an innovative empirical approach. We achieved this by assessing engineers and industry decision makers attitudes and behavioural intentions over magnesium alloys. Furthermore, we will investigate if individual differences characteristics and psychological traits might play a role on how attitudes towards magnesium alloys are formulated. Since previous research suggests that locus of control correlates negatively towards attitudes to use new technology whereas locus of control and affinity for technology positively (Caciopo, Petty & Kao, 1982).

We will conduct a scoping pilot study on the engineer's attitudes following the methodology of previous psychological research (Edison & Geisler, 2003) where attitudes towards new technology and brad names were investigated. Furthermore, we will investigate if the psychological constructs for Need for Cognition (Caciopo, Petty & Kao, 1982) as well as measurements for Affinity for Technology (Parasuramam, 2000), Tolerance for Ambiguity (McQuarrie & Mick, 1992) and Locus of Control (Rotter, 1966) could moderate the formulation of magnesium related attitudes.

Join Birmingham City University on 20th July for more insights on hidden benefits of Magnesium.

The Viability of Using Magnesium Alloys in Structural Components

Abed Alaswad – Lecturer, School of Engineering and the Built Environment

Abstract

Driven by the climate change issue, and the global response to it, a significant effort has been spent, over the last few decades, on the lightweight industry as it has been proven to lead to a less fuel consumption, less pollution, along with better drivability and performance. In this regard, Magnesium is considered to have an excellent potential as it is one of the lightest structural metals offering great weight saving. However, due to a number of technical and commercial obstacles, Magnesium has not been promoted effectively on a wide scale. Therefore, a good deal of research is needed to overcome these barriers, aiming towards bigger involvement of Magnesium in Automotive and Aerospace industries.

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If you're interested in finding out more about uses for Magnesium register now for our Magnesium Symposium on July 20th.

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A Perspective: Potential Growth in the Global Magnesium Industry – Environmental Impacts & Recyclability

Martyn Alderman - International Magnesium Association, European Committee Chairman
Email: martyn.alderman@magnesium-elektron.com

Abstract

Magnesium enjoyed considerable growth in the last decade of the twentieth century due to an increase in automotive die casting alloy applications for light-weighting. In spite of considerable research activity into wrought applications in the last fifteen years, the use of sheet and extrusions is largely limited to non-structural applications, primary batteries and small electronic devices (cameras, cell phones, lap-tops & tablets), and cathodic protection. The major volume use for magnesium metal remains as an alloying element for aluminium, and as a chemical reducing or microstructure modifying agent in the production of titanium, steel and SG iron. Powders are currently used in organic chemical reactions and as thermal decoy devices rather than for any structural purpose, however applications in energy storage devices continue to be actively pursued, and bioresorbable implants are beginning to gain market acceptance.

The International Magnesium Association exists to promote the end uses of magnesium and to represent the industry as a whole in issues that affect its members. In the last 5 years the IMA has sponsored a Life Cycle Study for magnesium being used in automotive and aerospace applications, a video to promote wider application of the metal, and an End of Life Scrap Study for the European Market. In spite of projected CAGRs of around 8% for the next 10 years, today global consumption of the metal remains less that 1 million tonnes and less than 2% of the size of the global aluminium market. This industry size today presents a challenge for the European Economy to promote the end of life recovery of the metal using fully functional recycling rather than allowing magnesium to be removed in aluminium refining operations.

To hear more on the research of the International Magnesium Association and gain access to their findings register free for Birmingham City University's Magnesium Symposium on 20th July.

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A Perspective: Supporting Women in Science and Engineering with BCU and Meridian Lightweight Technologies UK (MLTUK)

Laura Leyland

Well reported figures detail the lack of women in the engineering industry, for example, the IET Skills Survey 2016 reporting women make up only 9% of all engineering and technology employees. Gender diversity remains a huge challenge for the sector, including that of the casting industries. Birmingham City University (BCU) and Meridian Lightweight Technologies UK (MLTUK) are working together to develop opportunities to support women as they enter this exciting world of engineering.

New, more appealing courses

At Birmingham City University we are challenged with very low numbers of female undergraduates studying our engineering courses 5% which falls below the sector mean. We have recently undertaken a radical rewrite of our curriculum, taking the opportunity to widen the appeal of our courses which we will deliver from September 2017.

Support students and staff

To support the students and staff, BCU is an institutional member of Women in Science and Engineering (WISE) and we have a new WISE society.

Institutional support

We have been awarded Athena Swan Bronze award which supports our journey towards a more balanced work force.

Industrial support

Sponsored by MLTUK we have three student bursaries available. Potential students will be invited to apply, and the winning candidates will receive not only monetary support, but a valuable opportunity to spend a month working with MLTUK in the summer at the end of the first year of study. This will be in place for students starting their courses in September 2017.

Benefits for MLTUK

Talented engineering students to undertake project work. Opportunities to promote the magnesium industry while working towards a more diverse workforce.

Gain further insight into the work Birmingham City University are doing to support women in Science and Engineering at the Magnesium Symposium on 20th July. Register today.

References

Institute of Engineering Technology (2016) Skills and Demand in Industry Survey, (IET)

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Fuel Consumption and Carbon Emissions Reduction from Automobiles through Lightweighting

José Ricardo Sodré – Senior Lecturer, School of Engineering and the Built Environment

Abstract

A way to reduce automotive fuel consumption and, consequently, carbon dioxide (CO_2) emissions is the use of lightweight materials. Magnesium is a promising material for vehicle light weighting, as it is 33% lighter than aluminium and 75% lighter than steel or cast-iron components. The corrosion resistance of high-purity magnesium alloys is better than that of conventional aluminium die cast alloys. Magnesium alloys have distinct advantages over aluminium and ferrous materials by virtue of better manufacturability. Solidification is faster due to lower latent heat so that approximately 25-50% more castings can be produced per unit time compared to aluminium. Previous investigations concluded that 18 kg vehicle mass reduction improved fuel consumption by 0.07 L/100 km, ant the replacement of an engine cylinder block, front cover and oil pan from conventional materials by diecasting magnesium AZ91caused a reduction of 7% on total engine weight.

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A Testbed Platform for UVA Emergency Deployment

Fawaz Y Annaz - Reader in Mechatronics, School of Engineering and the Built Environment

Ian Hawkins and Steve Howard - Meridian Lightweight Technologies

Abstract

Despite the safety measures taken by manufacturer, accidents, fires, or even explosions still remain a daily reality. To reduce the likelihood of such events, prevention plays a very important part. Some of these measures include: housekeeping, work habits, workforce training, regular maintenance, equipment inspection and testing. It is also important to train staff, schedule emergency drills to identify weaknesses, check secondary emergency systems (lighting, pumps, ventilations, etc.), and update emergency contacts and any necessary first aid supplies.

Industries with die casting facilities need to carry out extra prevention precautions, such as clean and dry site maintenance, and other process precautions such as planned preheating, cooling and dust control. While prevention measures significantly reduce the damage and recovery time, they should always be accompanied by emergency action plans before, during, and after accidents take place.

The presented work fits within the prevention, emergency actions, and the aftermath of accidents. The final goal will be to deploy Unmanned Arial Vehicles (UAVs) within installations such as the Meridian, to search for survivors, and to assess damage, in the event of an accident. To achieve this, the research introduces the new concept of Hardware-Virtual Environment (UAV-VE) Coupling, and presents a testbed platform that allows a UAV to navigate a VE that duplicates real surroundings, such as the Meridian's (or other facilities such as: nuclear reactors, oil rigs, etc.). The testbed will be used to map accurate and calibrated UAV manoeuvres onto VEs, and vice versa. In the event of an accident, a trained operator will deploy a UAV to search the facility, through steering the UAV paths within the VE. The UAV will in turn transmit back live pictures and data to assess damage and report the presence of survivors. The approach will help rescue teams in evacuating survivors and also eliminate unnecessary risks to the team.

Moreover, this approach can also be used on regular basis to carry out maintenance inspections to areas around the plant that are not easily accessible, for example, roofs, ceiling and ventilation systems.

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Magnesium Alloy Die Casting Process Improvement using the Single Minute Exchange of Dies (SMED) Method and Other Techniques

Alan Pendry – Associate Professor, School of Engineering and the Built Environment

Abstract

In the die casting process the optimisation of machine capacity utilisation is a key goal in achieving economic throughput. The die changeover procedure is widely recognised as a possible area for reducing plant downtime. Following a visit to a sister plant, the SMED method has been applied and augmented by rationalisation of procedures. Identification of internal and external activities and moving activities off-line wherever appropriate was investigated, along with the elimination of Non-Value-Added activities wherever possible. There was also a bottleneck in the use of a single crane which may have been otherwise engaged when dies need to be changed. Other operating parameters will need to be investigated, including robotic loading and unloading. There are a number of challenges and opportunities for further downtime reduction, and this study is therefore on-going. The business case needs to be addressed and costs/benefits analysed. To this end, usage and order levels both before and after the Project will need to be monitored, and any new uptake identified. Changeover times at the UK plant have so far been reduced from 24 hours to an average of 6½ hours.

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Downtime Solutions to High Pressure Die Casts Exchange in the Meridian

Fawaz Y Annaz - Reader in Mechatronics, School of Engineering and the Built Environment

Ian Hawkins and Steve Howard - Meridian Lightweight Technologies

Abstract

High pressure die casting is the process of injecting (under high pressure) melted metal into a steel die. It is one of the fastest and most economical manufacturing techniques for mass-producing high quality metal components. Dies are reusable and are machined to the exact design of the component to be casted, where molten metals are either poured or injected into the mould. Die casting has the advantages of producing uniform components with good surface finish, accurate dimensions, and little post-machining. The process is suitable for producing high volumes of complex-shaped-thin-walled parts, with high degree of repeatability and accuracy.

Magnesium alloys enjoy unique solidification characteristics over other metals, thus they are said to have better castability. Unlike molten aluminium, magnesium does not attack iron, therefore, it can be melted and held in steel crucibles. Magnesium alloy casting goes back to 1921 when Dow Chemical began producing magnesium pistons, and by the World War II their casting technology was well developed.

The Meridian started magnesium die casting back in 1981, and remains to be the world's largest components producer. The company caters for international clients in the automotive industry. The process utilises heavy die casting machines with other secondary machining. To cater for different products, it is necessary to replace or exchange these heavy die casts. It is the time taken to shift or switch these dies that increases the downtime. The problem is further magnified when client companies place small orders, which makes the overall process economically unsound.

It is the aim of this research to improve downtime by proposing three innovative alternative die casting machines, along with alternative deploying mechanisms. These are: high-power-hydraulics-robot deployment of currently used die cast structures; robot deployment of light-weight-sliced-type structures; and robot deployment of light-weight-wedge-locked type structures.

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Vulnerability and Innovation

Clayton Shaw – Programme Manager, STEAMhouse

Abstract

What does it mean to collaboration with people from unfamiliar disciplines, and how can this lead to innovation?

BCU is embarking on an ambitious mission to contribute to the development of a community of people and organisations with a strong interest in supporting innovation. Through the STEAMhouse initiative, (connecting Science, Technology, Engineering, Arts and Maths), the team are busily working towards establishing a new centre for creative innovation. It will focus on bringing people together to coalesce around a problem or challenge with the aim of innovating practices, products, and services. This interdisciplinary way of working has many merits, and requires an open, trusting, and brave approach, often taking people outside of their comfort zones.

It may be a risky approach for some, who may feel that the risks are too great to consider participating in, but for others with a level of curiosity and willingness to share and receive ideas, it can be a deeply rewarding experience.

STEAMhouse will enable people to examine the world through different perspectives, and contribute to a growing community of likeminded individuals to break down silos, find new networks, and reframe what it means to innovate in the digital age.

If you'd like to find out more about the innovative work we're doing around Magnesium and STEAMhouse sign up today for our Magnesium Symposium on 20th July.

Evaluation of a strut top mount for a magnesium space frame structure for mainstream road cars.

Richard H. Cornish – International Magnesium Association, School of Engineering and the Built Environment, Birmingham City University
Email: richard.cornish@bcu.ac.uk

Abstract

The widespread use of magnesium castings in mainstream road vehicles is one way of reducing vehicle mass and hence fuel consumption. The use of magnesium alloys could be encouraged by a gradual improvement in the technical support available. The design limits could be stress based, but with better failure criteria, such as Christensen proposed. These criteria are more sophisticated than Von Mises and could provide a useful addition to the safety margin. In addition, the application of damage models caused by the growth and amalgamation of inclusions, will allow fatigue life and stress corrosion estimates to be refined. As better alloys and alloy systems become available, and the cost per kilogram weight saved increases, there should be enough of a margin to justify the increased design and analysis costs. Finally, vehicle quality and consistency will begin to improve pulling residual values and recycling activity upwards. Casting frames, joints and beams will reduce the structural variability of vehicle body structures. This should enhance vehicle safety, dynamics and refinement, and the proposition of car ownership in future.

To hear more on the research of the International Magnesium Association and gain access to their findings register free for Birmingham City University's Magnesium Symposium on 20th July