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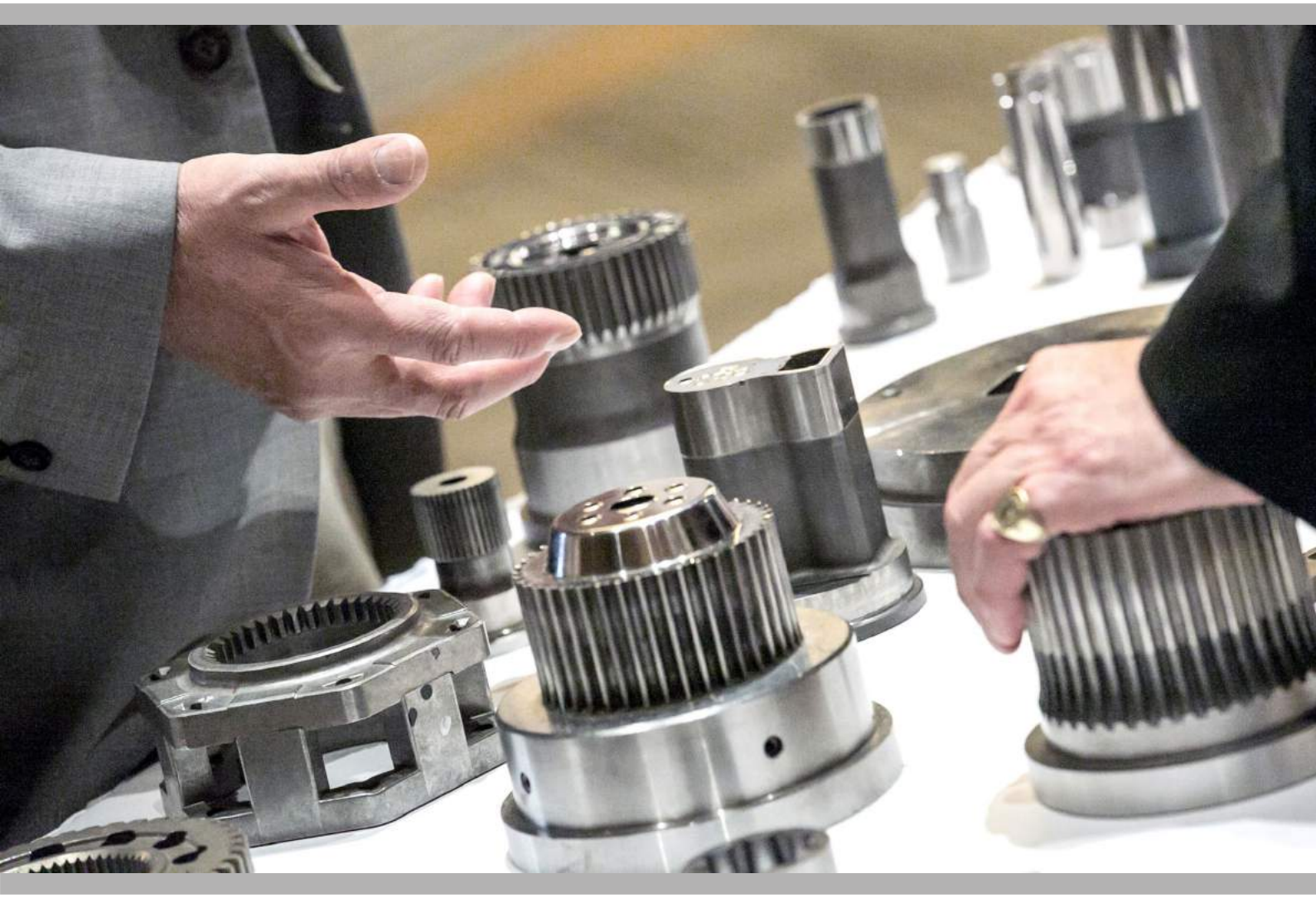
POWDER METALLURGY REVIEW



METAL POWDER INDUSTRIES FEDERATION

PM IN ELECTRIC VEHICLES

GREEN MACHINING

www.pm-review.com

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Submitting news and articles
We welcome contributions from both industry and academia and are always interested to hear about company news, innovative applications for PM, research and more.

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INOVAR COMMUNICATIONS

The importance of the industry trade association

The work of the trade association is essential to the development of the industry it represents. Whether promoting a technology to a wider audience, or representing the needs of its members on trade and regulatory issues, its activities are many and varied.

The Powder Metallurgy industry is fortunate in that it is represented by a number of well-supported and proactive industry trade associations in almost all regions of the world. North America is no exception. In this issue of PM Review we report on the work of the Metal Powder Industries Federation, in an exclusive interview with Executive Director Jim Adams (page 53).

The support of a trade association is at its most important during periods of significant changes in the markets its members serve, especially where the core of the industry finds itself at risk. The changing automotive landscape, shaped by growing demand for hybrid and electric vehicles, is of concern to many in the field of Powder Metallurgy.

However, with this threat comes opportunity. Also in this issue, we report on the European Powder Metallurgy Association's recent Functional Materials seminar, which brought industry and academia together to discuss the potential for PM applications in hybrid and electric vehicles (page 65).

Paul Whittaker
Editor, Powder Metallurgy Review

Cover image
The MPIF showcases the capability of PM technology (Courtesy MPIF)

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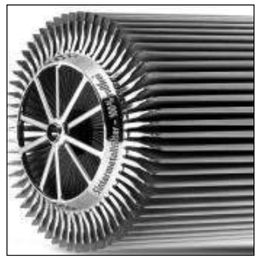
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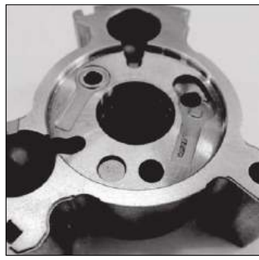
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in this issue

53 **Metal Powder Industries Federation: Education and technology promotion is key to PM's future**

The Metal Powder Industries Federation was established to represent and promote the North American Powder Metallurgy industry. Serving members in all sectors of the supply chain, the work of the MPIF is recognised globally. In an exclusive interview with Jim Adams, MPIF's Executive Director, we report on the work of the federation and share his unique perspective on the North American PM industry.

65 **Powder Metallurgy functional materials: Applications in electric vehicle manufacture**

The European Powder Metallurgy Association held its first Functional Materials Seminar at Forschungszentrum Jülich, Germany, April 17, 2018. The event was established primarily to consider the potential impact of vehicle electrification on the future of the PM industry, and to discuss the wide variety of PM functional materials that could find applications in new electric vehicles.

81 **Ceramitec 2018: Industry suppliers showcase the latest in metal powder processing technology**

Held every three years in Munich, Germany, Ceramitec is the leading trade fair for the international ceramics industry. For a number of years, the exhibition and accompanying conference have included a Powder Metallurgy stream. Dr Georg Schlieper visited Ceramitec 2018 for *PM Review* and interviewed a number of exhibitors who supply equipment to sintered parts manufacturers.

91 **Sumitomo Electric: Optimising green machining for integration into a high volume production line**

As the design complexity of automotive components increases, many parts makers are seeking to optimise processing steps to maintain the high levels of productivity that make PM a viable option. In this report, Japan's Sumitomo Electric Sintered Alloy discusses the successful integration of green machining in a high volume production line.

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industry news

To submit news for inclusion in *Powder Metallurgy Review* contact Paul Whittaker, paul@inovar-communications.com

Tenneco set to acquire Federal-Mogul in $5.4 billion deal

Tenneco, headquartered in Lake Forest, Illinois, USA, has signed a definitive agreement to acquire Federal-Mogul, Southfields, Michigan, USA, from Icahn Enterprises L.P. for $5.4 billion. Subject to regulatory and shareholder approvals and other customary closing conditions, the acquisition is expected to close in the second half of 2018.

Tenneco also announced its intention to separate the combined businesses into two independent, publicly traded companies through a tax-free spin-off to shareholders. The move, scheduled for the second half of 2019, will establish an Aftermarket & Ride Performance company and a Powertrain Technology company.

Brian Kesseler, Tenneco's CEO, stated, "This is a landmark day for Tenneco with an acquisition that will transform the company by creating two strong leading global companies, each in an excellent position to capture opportunities unique to their respective markets. Federal-Mogul brings strong brands, products and capabilities that are complementary to Tenneco's portfolio and in line with our successful growth strategies. Unleashing two new product focused companies with even stronger portfolios will allow them to move faster in executing on their specific growth priorities."

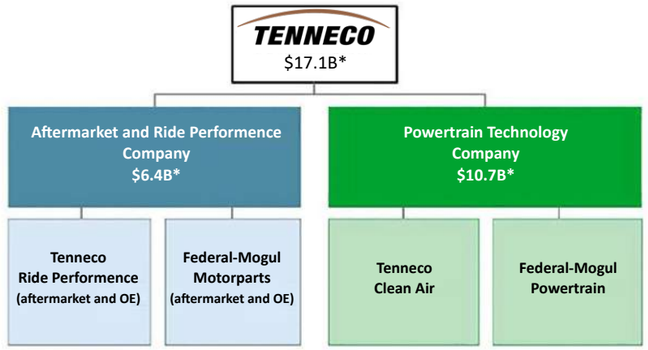
"Icahn Enterprises acquired majority control of Federal-Mogul in 2008 when we saw an out-of-favour market opportunity for a great company. During that time, we have built one of the leading global suppliers of automotive products," commented Carl C Icahn, Chairman of Icahn Enterprises. "I am very proud of the business we have built at Federal-Mogul and agree with Tenneco regarding the tremendous value in the business combination and separation into two companies. We expect to be meaningful stockholders of Tenneco going forward and are excited about the prospects for additional value creation."

The combination of Tenneco's Ride Performance business with Federal-Mogul's Motorparts business, forming the Aftermarket & Ride Performance company, will establish a global aftermarket presence with a portfolio of what it states are some of the strongest brands in the market, including Monroe, Walker, Wagner, Champion, Fel-Pro and MOOG. This broader aftermarket product coverage, stronger distribution channels, and enhanced channel development, is expected to strengthen its position in established and high growth markets such as China and India.

Through the combination of Tenneco's Clean Air product line and Federal Mogul's Powertrain business, Tenneco stated that the new Powertrain Technology company will provide a robust portfolio of products and systems solutions – from the engine to the tailpipe – that improve engine performance and meet tightening criteria pollutant regulations and fuel economy standards.

"Today's announcement is an extension of Tenneco's proven strategies for delivering profitable growth and will accelerate each company's ability to capitalise on trends that are fundamentally changing our industry," added Gregg Sherrill, Executive Chairman, Tenneco. "This is a major step forward in building an even stronger position with the combination of strategically aligned companies and the subsequent separation of the businesses, realigned in such a way to unlock shareholder value."

www.tenneco.com
www.federalmogul.com



*2017 pro forma total revenue

Post-close operating structure

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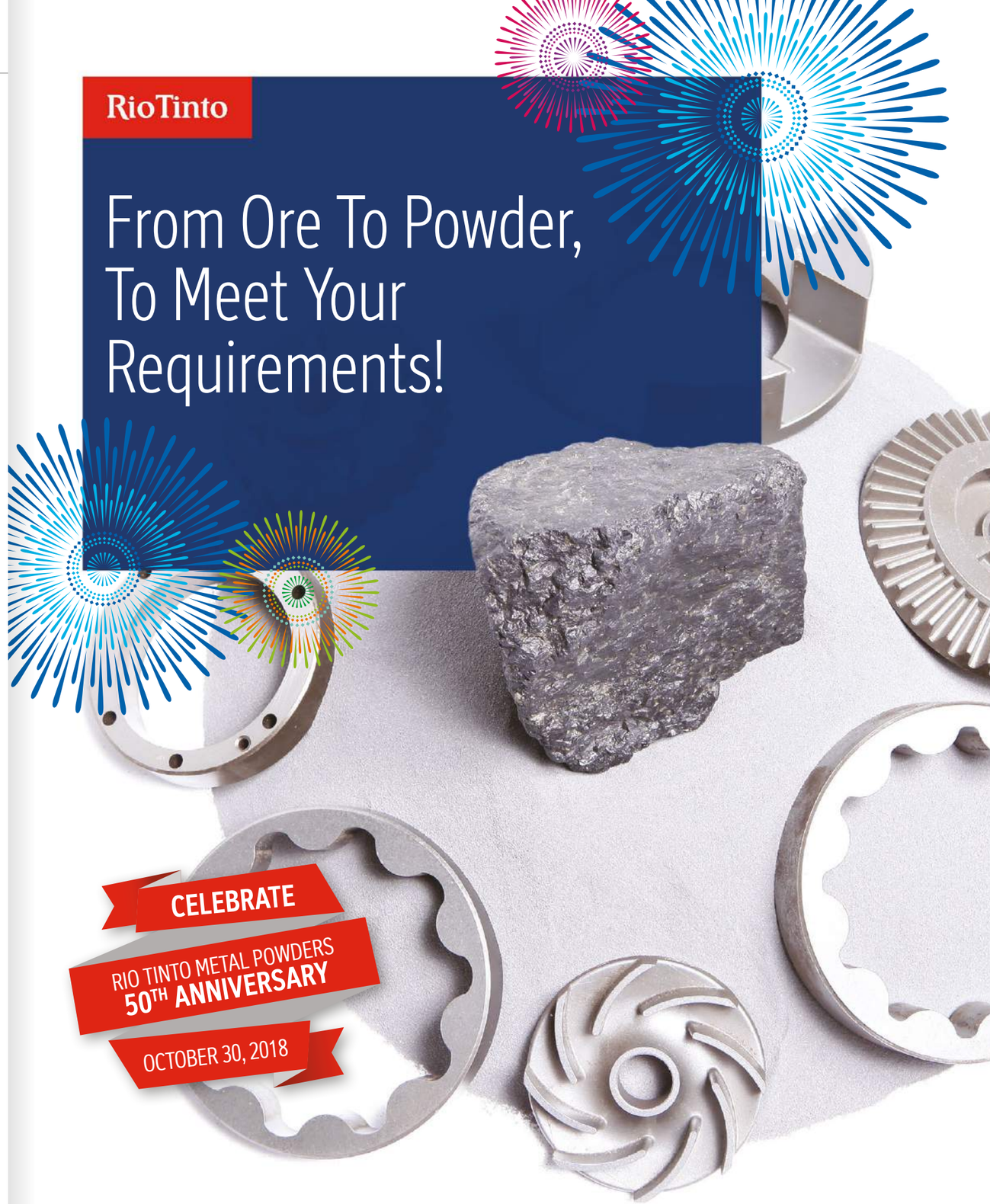


Melrose confirms takeover of GKN and appoints interim board

Melrose Industries plc has succeeded in its takeover of GKN plc after receiving the support of GKN's shareholders. The deal valued GKN at £8.1 billion and, in a further announcement published April 19, Melrose stated that its offer had become wholly unconditional and that it had acquired GKN shares representing over 75% of the voting rights of GKN.

"We are delighted and grateful to have received support from GKN shareholders for our plan to create a UK industrial powerhouse with a market capitalisation of over £10 billion and a tremendous future," stated Christopher Miller, Chairman of Melrose. "We are looking forward to working with GKN's talented workforce and to delivering for customers and all stakeholders. Melrose has made commitments as to investment in R&D, skills and people and we are very excited about putting these into action."

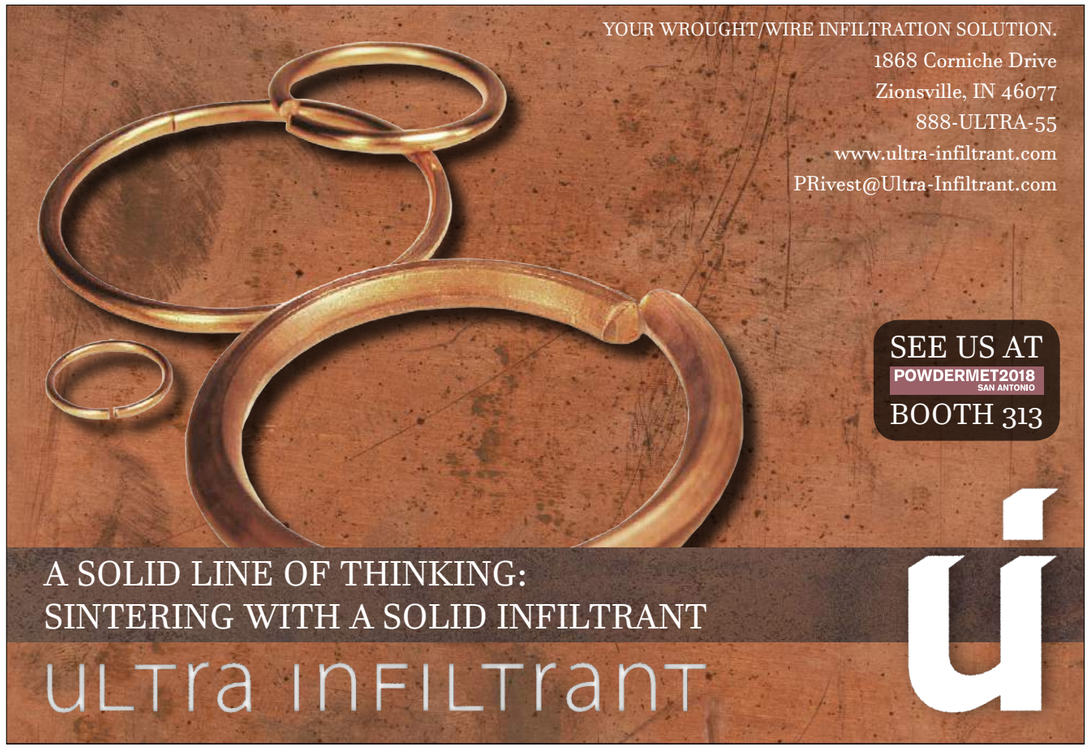
Following an initial proposal from Melrose to acquire GKN in January 2018, both companies had launched campaigns to convince GKN shareholders of their respective plans for the group, with both parties looking to sell the Powder Metallurgy business.

"Let me assure you that GKN is entering into very good hands," added Miller. "We would like to thank our shareholders for their continued support of the Melrose strategy thus far. We are full of enthusiasm as we begin this next stage of the Melrose story and look forward to creating substantial value for our shareholders, old and new."

Christopher Miller, Chairman of Melrose

GKN announced that Anne Stevens, a member of the company's board since 2010 and its Chief Executive since January 2018, has resigned along with the other members of the GKN Board including Chairman Mike Turner and Group Finance Director Jos Sclater. A new interim GKN Board was announced consisting of Christopher Miller, David Roper, Simon Peckham and Geoffrey Martin, who each currently serve as a director of Melrose, along with Jonathon Crawford and Garry Barnes.

www.gkn.com



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Sandvik reports strong start to 2018 with record operating profits

Sweden's Sandvik AB has reported a strong start to the year in its first quarter 2018 Interim Report. Order intake and revenues during the period improved organically year-on-year by 7% and 14% respectively, with positive development reported in all business areas. Operating profit also rose by 22% year-on-year to 4,271 million SEK, with the operating margin said to be at 18.0%.

"The year got off to a strong start with a broad-based increase in customer activity resulting in growth in orders and revenues as well as increased earnings and margins compared with the year-earlier period," stated Björn Rosengren, CEO and President of Sandvik. "In addition, we made further progress in relation to our active portfolio management. I am pleased with the performance of the Group."

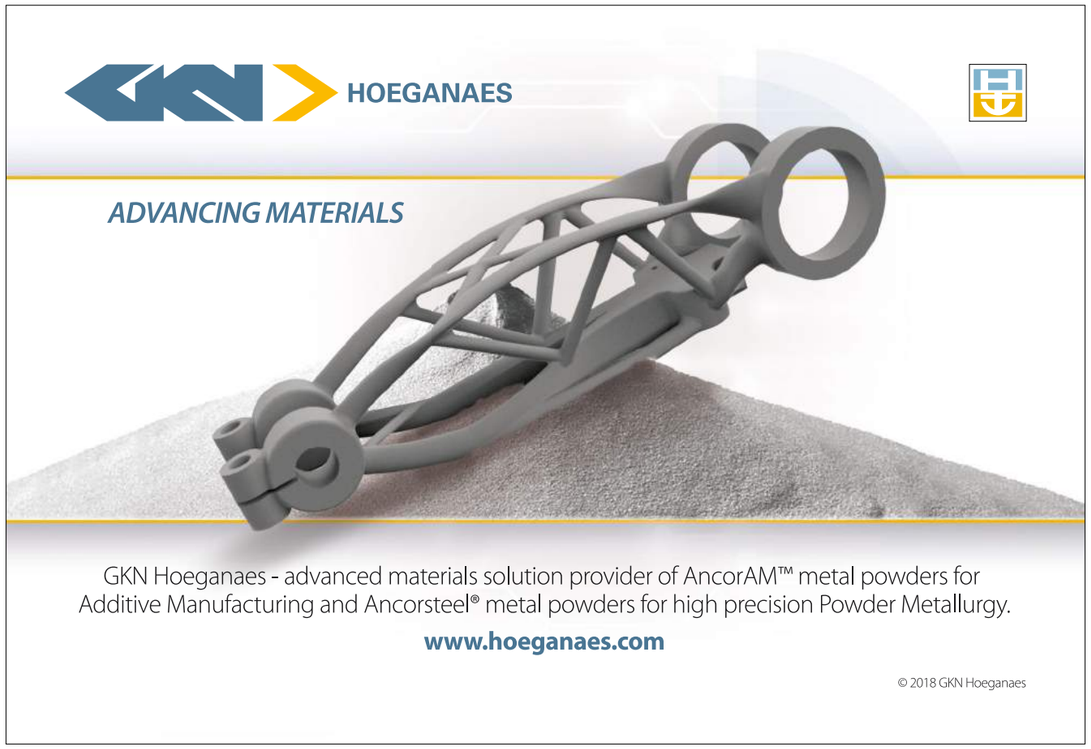
Sandvik Materials Technology reported an organic increase of 13% in orders and, excluding the impact of the large order received in the year-earlier period, orders increased by 27%. Sandvik Machining Solutions reported organic order growth of 8%. In Sandvik Mining and Rock Technology, orders improved organically by 4%, from the high level in the year-earlier period.

"Underlying demand improved in all business areas and geographical regions, yielding a book-to-bill of 107%. The strong growth in revenues supported operating profit, which increased by 22% to a record-high level of 4.3 billion SEK."

In the three major regions, Asia displayed strongest momentum with growth of 19%, supported by a significant increase in China. Europe improved by 6% with strong development across most countries. North America posted stable development with 0% growth, however order intake increased by 8% excluding the major order received in the year-earlier period.

During the quarter, Sandvik announced an investment of around 200 million SEK in a new plant for manufacturing titanium and nickel fine metal powders in Sandvik Materials Technology. It was stated that the new plant will complement the company's existing stainless-steel powder offering and thereby strengthen its position in the market for metal powder and metal Additive Manufacturing.

www.sandvik.com



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Miba to build second PM plant in China amid further expansion plans

Austria's Miba AG is to further expand its presence in China through the establishment of two new production facilities. In addition to a new plant for the manufacture of high-power resistors, the company is building a second Powder Metallurgy production facility close to its existing site in Suzhou near Shanghai.

Miba develops and produces sintered components, engine bearings, friction materials and coatings for the automotive and truck industry at its Miba Precision Components China (MPCC) site opened in 2007 in Suzhou. Since opening, revenue has increased fourfold from around RMB 200 million in 2010 to more than RMB 800 million, equivalent to over €100 million. The plant has undergone major expansion and the building space for production and offices has tripled in size from 8,000 to 24,000 m^2.

Unable to further expand its original site, Miba will construct a second, additional production facility a few kilometres away with around 10,000 m^2 of building space. Approximately €7.5 million will be invested in buildings and machinery, and construction is expected to be completed in around twelve months.

"Since 2007, MPCC has grown to become one of Miba's true successes. We managed to establish our business in China from the site in Suzhou, and now we will embark on our next growth phase," stated F Peter Mitterbauer, Miba CEO. "Miba is a globally operating group with over 7,000 employees in Europe, Asia, North and South America – our activities in China are making a substantial contribution to Miba's growth and success both today and in the future."

Acquisition of the industrial bearing segment of the John Crane Group

Miba is one of the leading global suppliers of engine bearings. In a move to expand the business through the development and production of industrial bearings, the company announced that it has acquired the industrial bearing segment of the John Crane Group. Three production sites in the US and one plant in Germany focus on the manufacture of hydrodynamic bearings for use in mechanical and plant engineering. The bearings are primarily used by customers in the energy and plant engineering industries, in high-performance applications such as turbines, compressors and industrial pumps.

Miba's new industrial bearings production sites will generate annual revenue of around €50 million. "By acquiring the John Crane industrial bearing segment, we aim to be a strong, global bearing specialist for engine bearings as well as for industrial bearings in the market," explained Mitterbauer.

Miba's existing PM facility in Suzhou, China (Courtesy of Miba)

Miba technology for electric vehicles

Miba also plans to expand its existing business. "For decades our Group has been an important and recognised partner to many of our customers in developing and producing highly efficient components for better energy efficiency, more environmental friendliness, greater precision and improved performance," added Mitterbauer.

Miba stated that it wishes to exploit the growth opportunities offered by new drive concepts such as hybrid technologies and pure electric driving. "Two years ago we established a central e-Mobility Innovation Lab, and are also focusing on electrification across all divisions," continued Mitterbauer. "Initial successes confirm we are on the right track. China is the world's largest sales market for electric vehicles. Miba has used this opportunity and its EBG high-power resistors are already being used in the pure electric vehicles of many major automotive manufacturers, including vehicles made by the world's largest manufacturer of electric cars." Miba is also developing and building production facilities for the construction of stators for electric motors on behalf of its customers, as well as offering its customer battery cooling technologies.

Demand for more than 2,000 additional employees worldwide

Miba currently employees a workforce of over 7,000 employees and, since 2010, has created around 4,300 new jobs worldwide. In the next three years the company states it will require over 2,000 more employees. "We need well qualified, skilled employees for our existing and strongly growing business," explained Mitterbauer. "In addition to external searches for new employees, we are also training around 220 apprentices, and have developed our own internal training and upskilling programmes. We are also permanently looking for technicians, sales representatives and developers, both for our existing business and for new growth areas related to the electrification of powertrain technologies and digitalisation."

www.miba.com

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Magnus Ahlfors, Quintus Technologies, LLC is giving the following presentation: "Cost Effective Hot Isostatic Pressing – a Cost Calculation Study for MIM Parts".

quintustechnologies.com

Quintus TECHNOLOGIES

EU project looks to demonstrate feasibility of High-Density PM process

LIFE 4GreenSteel is an EU/industry funded project which aims to demonstrate the feasibility of replacing traditional energy-intensive and material-consuming machining of wrought metals with a new and innovative High-Density Powder Metallurgy (HDPM) technology. In particular, the project is reported to be focusing on the manufacture of high-performance steel gears for the automotive market, utilising the recognised green credentials of the PM process.

The high mechanical and dimensional requirements could, it is stated, be theoretically met by means of an innovative Die Wall Lubrication (DWL) compaction stage, in combination with high-temperature vacuum sintering and thermochemical treatment. The DWL compaction process is currently used only in a limited number of applications and has not yet been exploited at an industrial level due to the difficulties of planning, managing and monitoring the production process.

The project, coordinated by Italy's TFM Automotive & Industry S.p.A, with partners including press manufacturer Sacmi, R&D company K4Sint, and the University of Trento, is expected to show a reduction in the use of raw materials by some 47% and energy savings of 50%, compared to the traditional machining process. Targets include the development of an effective pressing system to produce sintered steel parts that have a density greater than 7.3 g/cm^3 and high dimensional stability. It will tailor the high-temperature vacuum sintering stage and develop a reliable case-hardened profile of PM steel by means of the thermochemical treatment Low-Pressure Carburising (LPC).

In addition, the partners will use a chemical composition for steel that avoided harmful alloying elements, such as nickel, or alloying elements that make the recycling process difficult and ineffective, such as copper. It is stated the process will reduce by more than 70% the lubricant premixed with metal powder, so eliminating the burning stage, increasing energy efficiency and solving related emission problems.

LIFE is a financial division of the European Union that supports environmental safeguarding, nature conservation and climate change action projects. Since its founding in 1992, it has funded over 4,500 projects.

www.tfmgroup.it
www.sacmi.it
www.unitn.it
www.k4sint.com

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Johnson Electric reports record net income for its full year

Johnson Electric Holdings Limited, Hong Kong, has reported record net income for the twelve months ending March 31, 2018. Total group sales amounted to $3,237 million, an increase of 17% over the prior financial year, while net profit attributable to shareholders increased by 11% to a record $264 million.

The figures include sales contributions of $144 million from automotive PM parts maker Halla Stackpole Corporation. The Automotive Products Group (APG), Johnson Electric's largest operating division, achieved sales of $2,494 million including Halla Stackpole Corporation and AML Systems (acquired 2016). Excluding acquisitions and currency effects, APG's sales increased by 8%.

Commenting on the outlook for the business, Dr Patrick Wang, Chairman and Chief Executive, stated, "Heading into the new 2018/19 financial year, the business is performing well in the context of a global economy that is expanding – but at growth rates still below pre-crisis averages."

"Very robust demand for our motion products and solutions continues and, barring rising protectionist sentiment boiling over into a major trade war, we anticipate organic sales growth for the current financial year to be similar to the level achieved in 2017/18."

"In summary, I am excited by the growth trajectory of the business and optimistic that the investments we are making will position Johnson Electric for enduring success," he concluded.

www.johnsonelectric.com

Submitting news..

To submit news to *PM Review* please contact Paul Whittaker: paul@inovar-communications.com

Tiangong targets annual production of 5,000 tons of PM tool steel

China's Tiangong International Co., Ltd., Jiangsu, is reportedly planning to produce 5,000 tons of PM tool steels annually, as the domestic market continues to show rapid growth.

According to *Steelclik*, the annual demand for Powder Metallurgy tool steel in China is around 500 tons, growing at a rate of 30% to 40% per year. Currently, China is said to rely heavily on imports from producers in the US, Japan, Sweden and Russia.

Tiangong's investment in related equipment will see a first phase production of around 2,000 tons, rising to 5,000 tons per year. Established in 1981, the company manufactures a wide range of high speed steels, die steels and cutting tools.

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Bohler-Uddeholm becomes voestalpine High Performance Metals

It has been announced that Bohler-Uddeholm Corporation, USA, has been rebranded as voestalpine High Performance Metals Corporation. According to voestalpine, the decision was taken to reflect the ownership structure of the company which has been in place since 2007 when voestalpine AG acquired Bohler-Uddeholm AG.

The name change was said to align the United States brand globally with each of its sister companies. voestalpine AG owns a number of global brands alongside Bohler-Uddeholm, including eifeler and ASSAB.

voestalpine's High Performance Metals Division is a global leader for tool steel and a leading provider of high-speed steel, valve steel and other products made of special steels, as well as powder materials, nickel-based alloys and titanium. It is focused on producing and processing high-performance materials and customer-specific services including heat treatment, high-tech surface treatments and Additive Manufacturing processes. voestalpine AG added that eifeler Coatings Technology will be rebranded as voestalpine eifeler Coatings in the coming months.

www.bucorp.com

MPIF announces appointment of new association presidents

The Metal Powder Industries Federation (MPIF) has announced that Rodney Brennen has been appointed President of the Powder Metallurgy Parts Association (PMPA) and Michael Stucky has been appointed President of the Metal Injection Molding Association (MIMA).

Rodney Brennen, Metco Industries, Inc., St. Marys, Pennsylvania, is a current member of the PMPA Board of Directors and MPIF Finance Committee. Brennen has over thirty years in the PM industry and is a past member of the Board of Directors of APMI International.

Michael Stucky, Norwood Injection Technologies LLC, Dayton, Ohio, is Chairman of the MIMA Standards Committee and current member of the MIMA Board of Directors and MPIF Technical Board. Stucky served as co-chairman for MIM2017 and MIM2018, and has been a member of numerous POWDERMET and AMPM Program Committees.

www.mpif.org

ASTM International Committee's top annual award presented to Joseph Tauber

ASTM International's committee on metal powders and metal powder products (B09) has presented its top annual award, the Award of Merit, to Joseph M Tauber of Kennametal Inc., Latrobe, Pennsylvania, USA. The prestigious award, which includes the accompanying title of fellow, is ASTM's highest recognition for individual contributions to developing standards.

Tauber was honoured for technical expertise and outstanding contributions to the committee in the development of material testing standards, and for masterful leadership in other international standards organisations, especially with respect to cemented carbides and associated raw materials.

A member of ASTM International since 1999, Tauber is also a member of the ASTM committees on Additive Manufacturing technologies (F42) and wear and erosion (G02). In 2015, the committee on metal powders and metal powder products honoured Tauber with the Distinguished Service Award.

Tauber, a staff engineer, has previously served as a supervisor of chemical analysis and a laboratory technician for Kennametal Inc., and a lab instructor at St. Vincent College.

www.astm.org

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Volvo Cars aims for 50% of all sales to be electric by 2025

Following the news that all its new models will be available in either a mild hybrid, plug-in hybrid or battery electric vehicle in 2019, Volvo Cars has further announced that fully electric cars will make up 50% of its sales by 2025.

The company's strategy to generate half of its sales from electric cars by 2025 is said to position it as a powerful player in China, the world's leading market for electrified cars. The Chinese government plans to have new-energy vehicles account for more than 20% of the country's annual car sales by 2025, which equates to more than seven million vehicles based on Chinese government forecasts.

"Last year we made a commitment to electrification in preparation for an era beyond the internal combustion engine," stated Håkan Samuelsson, President and CEO of Volvo Cars. "Today we reinforce and expand that commitment in the world's leading market for electrified cars. China's electric future is Volvo Cars' electric future."

Volvo Cars produces the S90, S90L T8 Twin Engine and XC60 T8 Twin Engine in China, with all three of the company's China plants – Luqiao, Chengdu and Daqing – now producing either plug-in hybrid or battery electric cars. The T8 Twin Engine incorporates two permanent magnet synchronous motors, in conjunction with a 2.0l turbo charged internal combustion engine. The vehicle's high voltage Li-ion battery receives energy from grid charging as well as from regenerative braking.

China is Volvo Cars' largest individual market and this year delivered a 23.3% first quarter sales increase, contributing to the company's first-quarter global sales growth of 14%. Last year, sales of Volvo cars in China passed 100,000 units for the first time.

www.volvocars.com

The T8 Twin Engine technology provides all wheel drive through a combination of electric and internal combustion power (Courtesy Volvo)

Höganäs appoints Johanna Rosén and Paul Schrotti to board of directors

Sweden's Höganäs AB has appointed Johanna Rosén, Professor in Material Physics at Linköping University, and Paul Schrotti, recently appointed CEO for Lindéngruppen AB, to its board of directors. Jenny Lindén Urnes, former CEO of Lindéngruppen and board member since 2004, and Peter Gossas, board member since 2008, will leave the board.

On departing the board, Urnes commented, "Höganäs is a fantastic company and it has been extremely rewarding and fun to follow the company's development. I became a board member in 2004 and during now almost fifteen years, Höganäs has gone through a huge transformation. Paul Schotti will in his new role as CEO for Lindéngruppen replace me as owner representative."

Fredrik Emilson, CEO Höganäs, added, "We are very happy to have Johanna and Paul on-board. They will support Höganäs with their knowledge and experiences. Johanna with her great knowledge and competence within material design from the academia and Paul with his operative background. At the same time it is of course sad that Jenny and Peter have decided to leave and we want to thank them for their contributions during their years as members."

Kerstin Konradsson, CEO Boliden Smelters and board member since 2016, will take on Gossas's operative competencies within the board, while Lisa Kjellén, Manager for the business area Brazing, will replace Nils Carlbaum as employee representative.

www.hoganas.com

Paul Schrotti (right), new CEO for Lindéngruppen AB, and Johanna Rosén (left), Professor in Material Physics at Linköping University (Courtesy Höganäs)

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Eisenmann opens new sales and service office in Japan

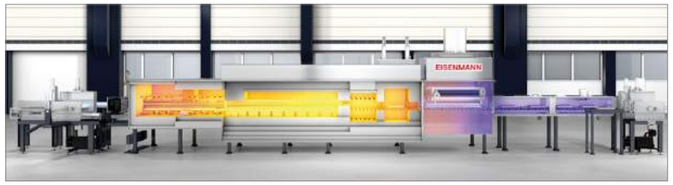
German plant engineering specialist Eisenmann is set to establish a new presence in Japan with the opening of a sales and service office in Yokohama, Kanagawa Prefecture. This new opening underlines the company's strategic goal of international growth and takes the total number of Eisenmann sites to twenty-six across fifteen countries.

The Yokohama office will reportedly focus on building and strengthening Eisenmann's business relationships with Japanese vehicle manufacturers and automotive component suppliers. Japanese OEMs account for approximately 30% of the global market for vehicles under six metric tons and have manufacturing facilities in many countries worldwide. However, capital expenditure decisions are significantly influenced by their corporate headquarters.

As Jeffrey Bowers, General Manager of Eisenmann Japan, explains, "The new office in Yokohama puts us in close geographical proximity to our local customers and allows us to engage more effectively with them. Japanese auto companies traditionally prefer to cooperate with locally based suppliers, but also pay close attention to quality and cost-effectiveness. As a result, they are increasingly interested in innovative technologies from other countries."

Eisenmann manufactures a range of furnaces for PM and MIM applications. The company's roller-type furnaces offer high-temperature sintering in multiple zones with temperatures of up to 1350°C, atmosphere separation and precise setting of the temperature profile. Very low dew points are said to permit dependable sintering of alloying elements with a high oxygen affinity such as chromium, manganese or vanadium. An integrated rapid cooling module permits sinter-hardening of new PM steels with tight dimensional tolerances.

www.eisenmann.com



Schematic of a furnace produced by Eisenmann (Courtesy Eisenmann)

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Quintus establishes new application centre at its Swedish HQ

Quintus Technologies has opened a new Quintus application centre at its headquarters in Västerås, Sweden. Supported by a team of specialists, customers will have access to a range of equipment with the aim of developing production processes and methods to optimise productivity.

In addition to meeting and training facilities, the centre is equipped with a Quintus Hot Isostatic Press (HIP). With typical pressures from 1,035 to 2,070 bar (15,000 to 30,000 psi) and temperatures up to 2,000°C (4,000°F), HIP can achieve 100% of maximum theoretical density and improve the ductility and fatigue resistance of critical, high-performance materials.

The Quintus application centre in Västerås, Sweden, will allow customers and partners to verify processes and materials before full-scale production

The centre also has a Fluid Cell Press, with an additional Deep Draw Press scheduled later this year, for sheet metal forming applications.

At the application centre the Quintus team, together with the customer, can perform pre-studies, validate, simulate and verify processes and materials. Quintus also arranges technical seminars and can provide the training needed to implement new solutions and products. As an additional service, Quintus can offer material testing together with an external partner to evaluate the chemical composition, microstructure, porosity, mechanical properties and fatigue properties of the tested samples.

www.quintustechnologies.com

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metal hot zone debinding and sintering vacuum furnace

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Metal Powder Products renamed MPP following acquisition of NetShape Technologies

Metal Powder Products LLC, headquartered in Westfield, Indiana, USA, will be renamed MPP as part of its efforts to integrate with the recently acquired NetShape Technologies. The company has undergone a rebranding exercise, with the launch of a new logo and updated website.

MPP provides custom-engineered Powder Metallurgy and Metal Injection Moulding (MIM) solutions for industrial applications. It is said to be a key company in the innovation of material formulation, sintering, densification and PM joining techniques, and has nine production facilities in the USA and China.

"The combination of Metal Powder Products and NetShape Technologies creates a world class manufacturing company that will allow MPP to provide exceptional value for our customers with solutions that utilise innovative custom-engineered products," stated Dennis McKeen, CEO of MPP.

At its facilities, MPP specialises in the production of various components, including custom-engineered gears and sprockets, complex structural parts, high-strength aluminium parts and components requiring unique mechanical and physical properties, for use in high stress, high wear and magnetic applications.

www.MPPinnovation.com

Japan sees rise in Powder Metallurgy production in 2017

According to figures released by the Japan Ministry of Technology and Industry (METI), and published in the JPMA's Newsletter No. 394, overall Powder Metallurgy production in Japan increased by 4.5% in 2017 to 97,357 tonnes.

Machine PM parts make up the largest segment at 88,484 tonnes, an increase of 4% over the previous year. Other sectors include PM self-lubricating bearings at 6,741 tonnes (+8.3%), sintered friction materials at 723 tonnes (21.3%), electric current collectors at 72 tonnes (+10.8%) and other PM products at 1,337 tonnes (+12.1%).

The total value of PM production in Japan in 2017 was given by METI as Yen 167,605 billion (US $1.557 billion), representing an increase of 7.8% on the previous year. The statistics also revealed that 94% of machine PM parts are used for automotive applications and that 63.3% of PM bearings were also used in the automotive sector.

Growth in the production of PM products largely reflects the success of the Japanese automotive industry which in 2017 showed an increase in car production of 6% to reach 8,347 million units of which 4,218 million were exported.

www.jpma.gr.jp | www.meti.go.jp

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JPMA elects new president and announces new board members

The Japan Powder Metallurgy Association (JPMA) has announced the election of Yoichi Inoue, Fine Sinter Co., Ltd, as its new president. Also announced at the association's General Assembly, May 17, 2018, was the appointment of a number of new board members.

Former JPMA president, Isamu Kikuchi, Porite Corporation, retired as president of the association but will remain a permanent member of the JPMA board.

www.jpma.gr.jp

Yoichi Inoue, of Fine Sinter Co., Ltd., has assumed the presidency of the JPMA (Courtesy JPMA)

Bodycote enters into 15-year contract with Rolls-Royce, announces new Specialist Technologies facility in USA

Bodycote has announced the signing of a fifteen-year contract with Rolls-Royce's Civil Aerospace business, expected to be worth over £160 million. The company will provide thermal processing services which include specialised vacuum heat treatment and Hot Isostatic Pressing (HIP), supporting Rolls-Royce's turbine blade facilities in Derby and Rotherham, UK.

The agreement is said to ensure the provision of Bodycote's specialist thermal processing capacity to support the growth of Rolls-Royce's large civil engine programmes; these include the Trent XWB, Trent 1000, Trent 7000, Trent 700 and Trent 900.

Bodycote's core business is to provide services that protect and improve the properties of metals and alloys, extending their operational life and making them safer. The company has over 180 accredited facilities in twenty-three countries and is the world's largest provider of heat treating and specialist thermal processing services.

New Specialty Stainless Steel Processes facility

Bodycote has opened a new facility for Specialty Stainless Steel Processes (S^3P), which increase mechanical and wear properties in stainless steel without adversely affecting corrosion resistance. The company states that the new facility, based in Mooresville, North Carolina, USA, will help to support manufacturing supply chains in the southeastern US.

Bodycote's S^3P technologies are used in the treatment of stainless steel, nickel-based and cobalt chromium alloys (including martensitic and precipitation hardened stainless steel materials) to improve resistance against surface wear such as galling, cavitation erosion and abrasive wear.

Demand for S^3P processes is said to have grown exponentially in the US, across multiple markets including automotive, food processing, medical and oil & gas among others. The new site will be accredited for both ISO9001 and AS9100 to serve the customer base.

www.bodycote.com

Sweden's SKF sees increasing demand for automotive bearings in China

SKF, headquartered in Gothenburg, Sweden, has reported seeing increasing demand for its bearings from China, where demand for electric cars means it is winning at least one new contract a month as suppliers adapt to changing automobile technology, reports Reuters.

Bernd Stephan, head of SKF Automotive, stated that while electric car sales were also rising in Europe, China was surging. "We have a huge gain of new business in this area ... There are so many projects popping up, and we are in a permanent discussion with these customers," he commented.

Electric cars are having a large impact on bearings manufacturers as they typically contain about half as many as a combustion engine car. While SKF is focused on parts such as bearings and seals, rivals including Germany's Schaeffler are developing full-electric drivelines. However, due to the fact that only 4% of its products go into combustion engines and wheel bearings are its biggest product, SKF stated that it has largely been shielded from this negative impact.

The automotive bearings market is intensely competitive and price sensitive and the rise of Chinese rivals has added to concerns over long-term profitability. However, Stephan stated that he saw no reason why SKF should not be able to handle its Chinese rivals, saying it could use cheaper steel and different components to bring down manufacturing costs for bearings which were not top end products. "Why should we be less competitive than they are? We have the same production as they do, we are not producing bearings only in Europe," he stated.

www.skf.com

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Gasbarre Press Division expands team

Gasbarre Products, Inc, DuBois, Pennsylvania, USA, has announced the addition of three key members to its Press Division team. Joining the company are Lesley Kline, Business Development Manager, Larry Dixon, Automation & IoT Program Manager and Matt Undercoffer, Customer Service Application Engineer – Electrical.

"The addition of Lesley, Larry and Matt allow us to better serve our customers, particularly with aftermarket products and services," commented Heath Jenkins, VP of Sales and Marketing for Gasbarre Press Division. "Gasbarre is pleased to have these valuable additions to our team and we, with their assistance, look forward to continuing to grow our ability to service our customers."

Lesley Kline has 20 years' experience in the Powder Metallurgy industry. As Business Development Manager, she is responsible for maximizing domestic powder metal capital equipment sales as well as aftermarket services and parts. Kline also assists in developing the strategies for the acquisition of new customers and for the retention of existing customers.

Joining the Gasbarre Press Division are (left to right) Lesley Kline, Larry Dixon and Matt Undercoffer

Larry Dixon will be responsible for managing the automation product offering for Gasbarre Press. He is accountable for the determination of customer needs, as well as for the design, deployment and installation of automated solutions to meet those needs.

Matt Undercoffer has joined the company as a Customer Service Application Engineer – Electrical. Undercoffer will be the main customer-facing representative for electrical issues, concerns or questions with installed equipment.

The Gasbarre Press Group, a subsidiary of Gasbarre Products, Inc, consists of four individual companies, with specialties ranging from mechanical and hydraulic presses, to high speed presses, as well as isostatic presses.

www.gasbarre.com

Isostatic Toll Services offers increased HIP capacity

Isostatic Toll Services (ITS) has commissioned a new Hot Isostatic Press (HIP) system at its site in Olive Branch, Mississippi, USA. The new HIP system is reported to reach temperatures up to 1260°C (2300°F) and pressures up to 138 MPa (20,000 psi).

The company recently passed its NADCAP AC7102/6 audit recertification for Hot Isostatic Pressing and is certified to ISO 9001 (Aerospace), ISO AS9100C (Aerospace) and ISO 13485 (Medical). It is also reported to have passed exhaustive onsite quality audits by MTU Aero Engines and Rolls Royce.

"This exciting expansion has increased our maximum pressure from 15,000 to 20,000 psi while increasing our production capacity," stated Braden Fleak, General Manager at Isostatic Toll Services. "All our HIP systems are dedicated to meeting the industry's high standards for quality"

ITS is a sister company of American Isostatic Presses (AIP), which has been in business since 1991 supplying companies all over the world with both Hot and Cold Isostatic Pressing units. "As a company, ITS has the unique advantage of gaining all the industry's technological improvements from AIP as well as having its equipment maintained by people and engineers who have been in the business for over 25 years," added Fleak.

www.isostatictollservices.com

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Japanese cutting tool supplier Osaka Kohki becomes Cominix

Cutting tool technology company Osaka Kohki Co Ltd, headquartered in Osaka, Japan, has been renamed Cominix Co Ltd following a recent rebranding exercise. The company is said to be a leader for cutting tool technology in the Japanese market and provides solutions for companies in the aerospace, automotive and electronics industries.

According to a report by *South China Morning Post*, the company is keen to work with suppliers in both developed and new markets, offering new solutions as well as the traditional solutions which it has been providing to companies such as Toyota and Nissan since the 1940s.

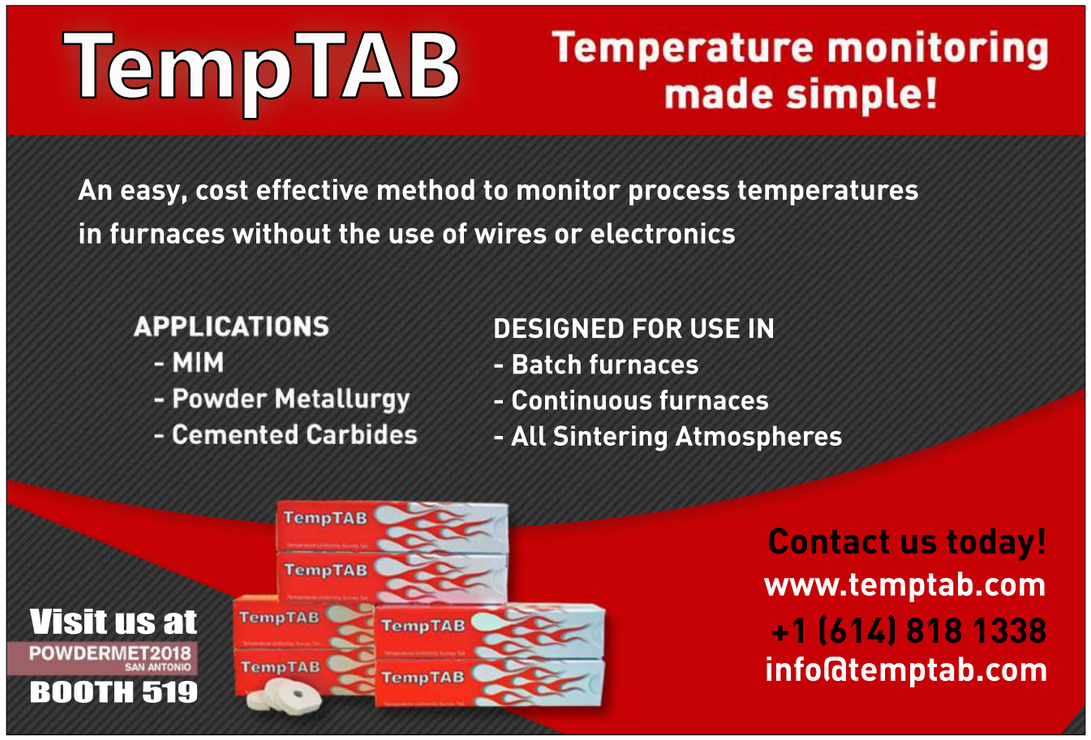
Cominix stated that the solutions it offers combine innovations from around the world, and that it will continue to draw on the knowledge of a number of manufacturers of cutting and wear-resistant tools, optical products and related accessories. In 2016, the company opened a technological laboratory in Japan to enhance its development of new customer solutions.

Shigemasa Yanagawa, President and Representative Director of Cominix, stated, "We find the best products from around the world. We have close relations with our customers, know their needs and pick out the best available products in places such as Germany, South Korea, the United States, Israel, Switzerland, Sweden, and of course, here in Japan."

Cominix has bases in six Asian countries as well as an established presence in Mexico and the US. According to the company, it expects to add five more branches to its network of offices and facilities over the next few years. The company's Japanese facilities are said to employ roughly two-hundred employees, creating solutions with new materials such as carbides and ceramics as well as new applications for hard metals and alloys.

"We focus on creating cutting tools that improve our customers' productivity," added Yanagawa. "They find our solutions appealing because we provide products that are affordable and last a long time. We are the number one company in Japan in cutting tool technology because we are trustworthy. Our goal is to expand further overseas so that we can contribute more to society."

www.cominix.jp



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Dr David Whittaker to receive 2018 Ivor Jenkins Medal

The UK's Institute of Materials, Minerals and Mining (IOM^3) has named Dr David Whittaker, CEng, FIMMM, as recipient of its 2018 Ivor Jenkins Medal. The prestigious award is presented to individuals in recognition of a significant contribution that has enhanced the scientific, industrial or technological understanding of materials processing or component production using Powder Metallurgy and particulate materials.

Dr Whittaker has over 34 years' experience in Powder Metallurgy technology, with a career split between industrial research and development and independent technical consultancy. In both roles, he has established international recognition for his high level of expertise.

In the field of industrial research and development, Dr Whittaker has led world-leading PM product and process development programmes at the level of Technical Director for GKN Powder Metallurgy Division and at T&N/Federal-Mogul. These programmes have included the design and development of press/sinter PM automotive connecting rods (a world first), process development for surface-densified PM transmission gears, variable valve timing system development and the development of assembled camshafts with powder metal lobes.

As a consultant, he has pursued a wide range of assignments for a broad customer base, including those in industry, trade associations, government and European Union organisations and academia.

Dr David Whittaker has been named as recipient of the 2018 Ivor Jenkins Medal

Dr Whittaker has written for leading technical journals and publications around the world, and since 2007 has served as Consulting Editor to *Powder Injection Moulding International*, *Powder Metallurgy Review* and *Metal Additive Manufacturing* magazines.

He has been active with IOM^3 as a member of the Powder Metallurgy Committee (1984 – 1990) and of the Particulate Engineering Committee since 2010.

www.iom3.org

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AMG reports positive start to 2018

AMG Advanced Metallurgical Group N.V. has reported first quarter 2018 revenue of $308.4 million, a 20% increase from $258.0 million in the first quarter 2017. EBITDA for the first quarter 2018 was $44.5 million, a 35% increase from $33.0 million in the first quarter 2017. Net income attributable to shareholders increased 18% to $18.4 million in the first quarter 2018 from $15.6 million in the first quarter 2017.

Dr. Heinz Schimmelbusch, Chairman of the Management Board and CEO, stated "AMG achieved a considerable improvement in profitability during the quarter, driven by improved pricing and higher sales volumes in AMG Critical Materials. In addition, continuing strong demand for our industry leading vacuum furnace solutions resulted in the highest quarterly order intake in ten years and the highest order backlog in over nine years."

AMG Critical Materials generated EBITDA of $37.1 million during the first quarter 2018, an increase of 44% from $25.7 million in the first quarter of 2017, thanks to strong financial performance in vanadium, silicon, titanium alloys, graphite, chrome and aluminium, driven by higher vanadium and silicon metal prices, and strong sales volumes.

AMG Engineering achieved EBITDA of $7.4 million during the first quarter 2018, a slight increase from $7.3 million in the first quarter 2017. AMG Engineering signed $104.8 million in new orders during the first quarter 2018, representing a 1.74x book to bill ratio, driven by strong orders of turbine blade coating and Powder Metallurgy furnaces for the aerospace market, heat treatment furnaces for the automotive market and induction heated quartz tube (IWQ) furnaces for fibre optic applications. Order backlog was $255.8 million as of March 31, 2018, an increase of 24% compared to December 31, 2017.

In the first quarter of 2018, AMG generated cash from operating activities of $24.8 million, an increase of $7.0 million compared to the same period in 2017. As a result of the strong cashflow generation, AMG's net debt decreased by $0.9 million in the first quarter of 2018, despite capital expenditures of $22.6 million during the period. In summary, the Company is operating at record levels.

www.amg-nv.com

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Harper adds HC Series configurable rotary furnaces to its range

Thermal processing solutions provider Harper International, Buffalo, New York, USA, has launched the HC Series™ Configurable Rotary Furnace product line. The HC Series is a standard set of rotary furnaces which are configured or customised to order and are available in a number of variations, depending on customer specifications.

The configurable designs take into account the required specifications for temperature, tube length, heated length, diameter and number of zones. A product selector on the Harper website is said to allow customers to select these specifications, after which a suitable rotary furnace design configuration is formulated.

Paul Elwell, Harper's Vice President of Sales and Marketing, stated, "We are excited that the HC Series allows Harper to virtually eliminate a number of up-front design engineering process steps, greatly reducing start-up lead times while offering a more standard product line to those customers looking for off-the-shelf solutions.

"Additionally, the web-based product selector tool provides an efficient head-start to our client engagement activities," he concluded. Harper International provides complete thermal processing solutions and technical services essential for the production of advanced materials globally, covering a range of customer requirements from research-scale solutions to full production lines.

www.designmyrotary.com
www.harperintl.com

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Höganäs establishes Inductor Systems Centre of Excellence

Höganäs has announced a new centre of excellence that will focus on the company's range of metal powder-based high-performance inductors. The Höganäs Inductor Systems Centre of Excellence was introduced at PCIM Europe 2018, June 5-7, Nuremberg, Germany, where experts from the centre were on hand to discuss Höganäs' Inductit® inductor products.

The new centre is said to offer application development, swift design work, fast prototyping, testing and all the support needed to develop unique power electronics applications at the lowest total cost.

Inductit is a compact, high-performing inductor based on metal powder technology from Höganäs. By using iron powder with significantly improved magnetic performance, in combination with highly efficient Pot Core geometry, Höganäs has been able to reduce the inductor's size and weight to make it more compact than any conventional solution.

Being made from iron-based recycled metal powders in a virtually zero waste process, the new inductor minimises the consumption of raw materials. Thanks to the efficiency-enhancing shape of Inductit and the unique properties of the material itself, performance is reported to be improved, resulting in drastically lower energy losses.

The compact inductor is set to pave the way for the production of slimmer, more streamlined inverters that can be fitted into smaller spaces and work more efficiently.

www.hoganas.com/inductit

Inductit offers a compact, high-performing inductor with an efficiency-enhancing shape and unique material properties

Japanese study reports discovery of 16 million tons of rare earths on seabed

A study published by Japanese researcher Yutaro Takaya, from Tokyo's Wasada University, states that an estimated 16 million tons of rare earth elements have been identified in sea sludge off Japan's Minamitorishima Island. In the study, Takaya stated that his team hopes to develop ways of extracting the materials within five years.

Certain rare earths, primarily neodymium and praseodymium, are used in the manufacture of high-performance permanent magnets which, as well as being a key enabler of hybrid and electric vehicles, are used extensively in the automotive industry to produce electric components such as those found in seats, mirrors, wipers, steering and braking.

Currently, China controls 90% of the rare earths market, due to the high concentration of rare earth deposits within its borders. Of the 120 million tons of land-based rare earth deposits globally, 44 million are said to be located in China, 22 million in Brazil and 18 million in Russia. Prices of Chinese rare earths are currently rising due to the stricter enforcement of its mining laws and a global surge in the demand for hybrid and electric vehicles.

As the second largest consumer of rare earths globally, Japan is one of many countries working to decrease its reliance on Chinese exports. Takaya stated that the find "should contribute to the 'resource security' of Japan," as well as having strategic importance in future negotiations. He explained, "Japan will be able to say, 'if prices are made to go above this level, we can look into developing seabed rare earths.'"

www.waseda.jp

Rainbow reports successful first phase drilling

Rainbow Rare Earths Ltd, London, UK, has reported on the success of its maiden drilling campaign at its Gakara Project, in the Republic of Burundi. Gakara is said to be one of the highest grade rare earth element mining projects globally, with an estimated in situ grade of 47-67% total rare earth oxide. Rainbow expects rare earth element production rates of 5,000 t per year by the end of 2018.

Rainbow began Phase 1 of its Gakara drilling campaign in the first quarter of 2018. The company also commenced drilling at the Kiyenzi prospect, where a high-priority gravity anomaly (indicative of rare earth deposits) had been identified, as well as a number of anomalies revealed by an airborne magnetic survey obtained in Q4 2017.

www.rainbowrareearths.com

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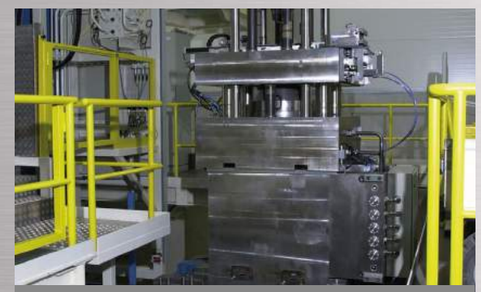
POWDER PRESS TECHNOLOGY

HPM 1200 E5 powder press



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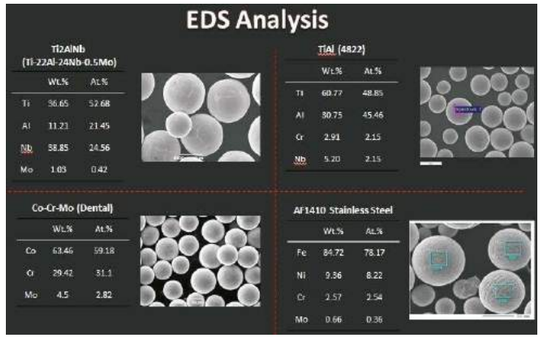

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Upcoming shows

Date	Exhibition	Place		Booth
16-20 September 2018	World PM 2018	Beijing,	China	A113
07-10 October 2018	Titanium Conference	Las Vegas,	USA	104
14-18 October 2018	Euro PM2018	Bilbao	Spain	157
13-16 November 2018	Formnext	Frankfurt	Germany	First Floor

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www.c-semt.com
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Sino-Euro

SUPREME consortium reports on plans for PM process optimisation

SUPREME is an EU funded project aimed at optimising Powder Metallurgy processes throughout the supply chain. Consisting of a consortium of seventeen partners from eight countries, the three-year project was launched in September 2017 with an EU contribution of €8 million.

By offering more integrated, flexible and sustainable processes for powder manufacturing and metallic parts fabrication, the project is looking to enable the reduction of raw material resources (minerals, metal powder, gas and water) while improving energy efficiency.

At a review meeting, held January 16-17, 2018 at CEA in Grenoble, France, partners were asked to review proposed value chains describing a baseline and a final SUPREME process to build five demonstrators in aeronautics, mould inserts, cutting tools, medical implant and automotive value chains. The session was aimed at sharing a common view on value chains and helped partners to understand the environmental KPIs on resource and energy efficiency, production rates and CO_2 emissions.

www.supreme-project.com

Dritev congress to showcase latest powertrain and transmission developments

The International VDI Congress 'Dritev – Drivetrains for Vehicles' has announced the speaker line-up for this year's event. Taking place in Bonn, Germany, June 27-28, 2018, the congress is expected to attract over 1,500 delegates and around 100 international exhibitors to what is said to be one of the world's largest networking platforms for powertrain and transmission development.

The two-day event will offer a technical conference programme reflecting current challenges and developments in automotive transmissions. The programme includes presentations from leading automotive manufacturers and suppliers.

An accompanying trade exhibition will host national and international companies presenting innovative solutions. Here, participants are expected to get an overview of the most important suppliers in the development, simulation and production of transmissions and transmission components.

www.dritev.com

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PM China 2019 moves to new venue as region's largest Powder Metallurgy exhibition continues to grow

PM China 2019 will be held at Shanghai World Expo Exhibition & Convention Center, Shanghai, China from March 25–27, 2019. Organised by Uniris Exhibition Shanghai Co., Ltd, the move to a new venue, said to be the largest indoor exhibition hall in Asia, is in response to the event's continued growth.

This year's event, PM China 2018 (The 11th Shanghai International Powder Metallurgy Exhibition & Conference), was held at Shanghai Everbright Exhibition Center, March 25–27, 2018, and ran concurrently with CCEC China 2018 (The 11th Shanghai International Cemented Carbides Exhibition & Conference) and IACE China 2018 (The 11th Shanghai International Advanced Ceramics Exhibition & Conference).

The joint events were reported to have a total exhibition area of 22,000 m^2, and listed 415 exhibitors from 18 countries and regions, including China, USA, Germany, UK, Italy, France, Netherlands, Sweden, Switzerland, Austria, Russia, Canada, Japan, South Korea, Singapore, India, Hong Kong and Taiwan. The organisers stated that the number of visitors for 2018 grew by 19% compared to the previous year, with a total of 18,219 professionals visiting the show.

In addition to the exhibition, several academic forums were arranged at the event, including the 7th Shanghai International Powder Metallurgy Technology Summit Forum.

www.en.pmexchina.com

PM Technology and Business Forum set for Yangzhou, China

The 2018 PM Technology and Business Forum will be held from June 21-23 in Yangzhou New Century Hotel in Yangzhou of Jiangsu Province, China, and is expected to attract a large number of PM and MIM parts and equipment manufacturers. Technical sessions will be held during the forum, with a number of industry experts invited to discuss and provide solutions on a range of production problems.

Topics discussed during the event will focus on industry trends including the development of hybrid and electric vehicles and their impact on the PM industry, fine control of manufacturing process costs for PM parts, automatic analysis of the whole the PM production process and information for those looking to enter the MIM/PIM industry.

www.fmyj.org

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Bosch diesel technology to drastically cut NOx emissions

New developments from Germany's Bosch Group could enable vehicle manufacturers to drastically reduce emissions of nitrogen oxides (NOx), resulting in levels up to ten times lower than the limits scheduled to come into force from 2020. Even in real driving emissions (RDE) testing, emissions from vehicles equipped with the new Bosch diesel technology are reported to be significantly below current limits of 168 milligrams of NOx per kilometre, resulting in as little as 13 milligrams of NOx.

"There's a future for diesel. Today, we want to put a stop, once and for all, to the debate about the demise of diesel technology," stated Bosch CEO Dr Volkmar Denner, speaking at the company's annual press conference.

Bosch engineers are said to have achieved this breakthrough with a combination of advanced fuel-injection technology, a newly developed air management system, and intelligent temperature management. As the measures to reduce NOx emissions do not significantly impact consumption, the diesel retains its comparative advantage in terms of fuel economy, CO_2 emissions, and therefore climate-friendliness.

"Bosch is pushing the boundaries of what is technically feasible," Denner added. "Equipped with the latest Bosch technology, diesel vehicles will be classed as low-emission vehicles and yet remain affordable."

Since 2017, European legislation has required that new passenger car models tested according to an RDE-compliant mix of urban, extra-urban, and freeway cycles emit no more than 168 milligrams of NOx per kilometre. As of 2020, this limit will be cut to 120 milligrams. It was reported that even when driving in particularly challenging urban conditions, where test parameters are well in excess of legal requirements, the average emissions of the Bosch test vehicles are as low as 40 milligrams per kilometre.

Even with this technological advance, the diesel engine has not yet reached its full development potential, the company stated. Bosch now aims to use artificial intelligence to build on these latest advances, resulting in the development of a combustion engine that – with the exception of CO_2 – have virtually no impact on the ambient air.

"We firmly believe that the diesel engine will continue to play an important role in the options for future mobility. Until electromobility breaks through to the mass market, we will still need these highly efficient combustion engines," Denner added.

Bosch has tested its diesel technology in a full range of driving conditions and reports results of as little as 13 milligrams of NOx per km

The CEO's ambitious target for Bosch engineers is the development of a new generation of diesel and gasoline engines that produce no significant particulate or NOx emissions. Denner wants future combustion engines to be responsible for no more than one microgram of NOx per cubic metre of ambient air – the equivalent of one-fortieth, or 2.5%, of today's limit of 40 micrograms per cubic metre.

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voestalpine begins construction of advanced special steel plant in Austria

A recent ground-breaking ceremony has marked the official start of a three-year construction phase for the new €350 million voestalpine special steel plant in Kapfenberg, Austria. From 2021 onwards, the plant will produce around 205,000 tons of high-performance steels a year.

Once operational, the new high-tech special steel plant is intended to replace the existing voestalpine Böhler Edelstahl GmbH & Co KG plant in Kapfenberg and is designed to produce premium quality pre-materials for aircraft components, tools for the automotive industry, equipment for oil & gas extraction, and for the Additive Manufacturing of highly complex metal parts.

"Today's ground-breaking ceremony for the new plant is not only a milestone for our group, and Kapfenberg as a location, but also a positive signal for European industry, as this is the first investment in a completely new steel plant in decades," stated Wolfgang Eder, Chairman of the Management Board of voestalpine AG.

voestalpine's High Performance Metals Division is the global market leader for tool steel and a leading provider of high-speed steel, valve steel, and other products made of special steels, as well as powder materials, nickel-based alloys, and titanium. It is focused on producing and processing high-performance materials and customer-specific services including heat treatment, high-tech surface treatments, and Additive Manufacturing processes.

"This investment provides voestalpine with a global technological lead and cost advantage in manufacturing high-performance steels, and allows us to remain globally competitive over the long term, even when producing at a traditional European location," added Eder.

In the business year 2016/17, the High Performance Metals Division reported revenue of around €2.7 billion and an operating result (EBITDA) of €395 million. The division has around 13,700 employees worldwide. In total, during business year 2016/17, the voestalpine Group generated revenue of €11.3 billion and an operating result (EBITDA) of €1.54 billion with around 50,000 employees worldwide.

www.voestalpine.com

The ground-breaking ceremony marked the official start of construction at voestalpine's special steel plant in Austria

HyGear signs deal to supply major PM company with hydrogen

HyGear, Arnhem, the Netherlands, a supplier of industrial gases through on-site generation technology, has announced the signing of a long-term supply contract for industrial hydrogen to a leading global metallurgy company. The company will use the hydrogen in its large-scale sintering process.

Pure hydrogen gas is often used as an effective atmosphere for high-temperature sintering of metal powders. Hydrogen helps to maximise corrosion resistance, reducing surface oxides and removing impurities from various alloys.

HyGear will install its widely-applied Hy.GEN technology to deliver the base-line supply by generating hydrogen at the customer's site. In addition, its growing trailer fleet will be deployed to guarantee supply flexibility in cases of temporary demand increase. This set up offers the most cost-effective and reliable hydrogen supply for this critical application.

"The signing of this contract helps us strengthen our presence in the metal industry, which is our third growing market after the flat glass and food industries. Although our technologies are not limited to certain industrial applications, we feel that our industry-focused roll out strategy leads to better understanding of our customers' needs. It also allows us to tailor our solutions in such a way that we will always offer the most cost-effective and reliable overall solution", stated Niels Lanser, HyGear's Director of Sales and Marketing.

"We are also performing research and development works to further reduce costs by recycling the gases used in the process. We are currently implementing this technology in the glass industry and our next step is to develop products dedicated to the metal industry as well," added Lanser.

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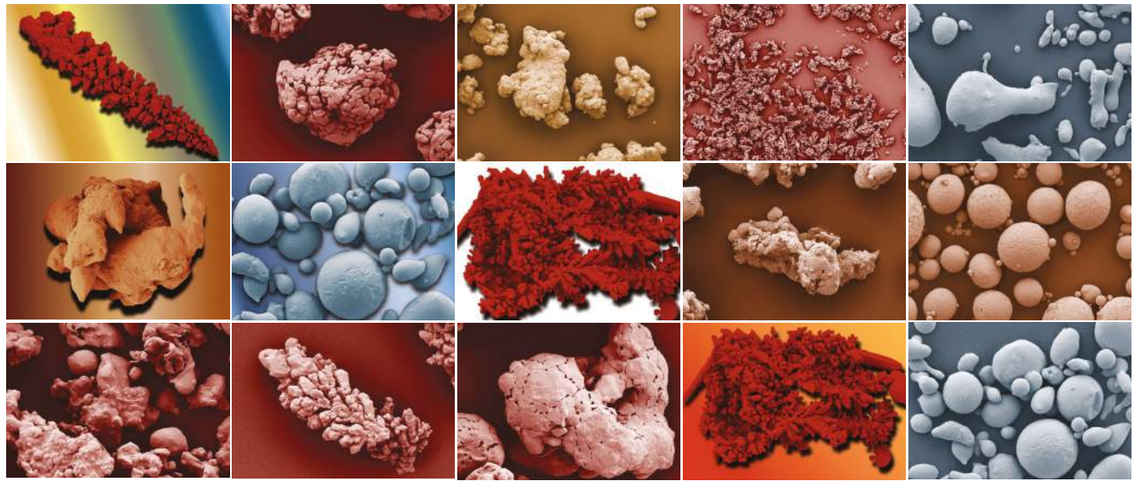

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Toyota to introduce ten new electrified vehicles in China by 2020

Toyota Motor Corporation has announced that it plans to introduce ten new electrified vehicles in China by the end of 2020. The automaker also stated it plans to begin producing certain models of plug-in hybrid electric vehicles (PHEV) in China, marking Toyota's first overseas production of PHEVs.

Toyota will begin marketing new PHEV versions of its Corolla and Levin passenger cars in 2019 and a battery electric vehicle (BEV) model based on its C-HR/IZOA compact SUV in 2020. By further promoting its local production of electric motors (powertrain components), batteries, inverters, and other electrified-vehicle core technologies, Toyota aims to further accelerate its China-based vehicle electrification efforts.

With an aim to achieve locally based vehicle electrification, Toyota has been working with its Chinese partners and members of the Toyota Group to build a local production base for key components. Efforts have included the launch in 2015 of production of transaxles for hybrid electric vehicles at Toyota Motor (Changshu) Auto Parts Co., Ltd.

Going forward, Toyota intends to respond to further expected growth in demand for electrified vehicles through such measures as increasing the annual production capacity for nickel-metal hydride battery modules at Sinogy Toyota Automotive Energy System Co., Ltd. and Corun PEVE Automotive Battery Co., Ltd. to 220,000 units in 2020.

Toyota is also strengthening its local R&D and production bases. In 2020, it plans to open a new battery testing facility at Toyota Motor Engineering & Manufacturing (China) Co., Ltd. (TMEC), which is Toyota's R&D centre in China, for evaluating battery packs for electrified vehicles.

The company added that it is also exploring potential applications for its fuel cell technology in China. Last year, it began a three-year verification-test program in China that uses Toyota's Mirai fuel cell electric vehicle and it has expanded the scope of feasibility studies to include commercial vehicles such as buses.

"We are steadily and confidently advancing all aspects of our environmental strategy in China, the world's most-advanced country in electrification," stated Toyota Senior Managing Officer and Chief Executive Officer, China Region, Kazuhiro Kobayashi.

www.toyota.com

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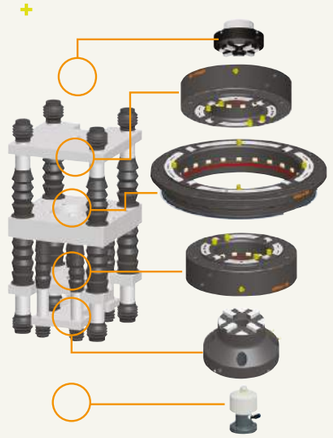

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Sandvik rewards best-selling cemented carbide development team

The development of a cemented carbide grade for steel milling, designed to prolong insert tool life, has led to the award of Sandvik's 2018 'Wilhelm Haglund Medal to the Product Developer of the Year' to a team of scientists at Sandvik Coromant. Karin Andersson, Björn Ericsson, Emmanuelle Göthelid and Marie Pettersson were presented with the medal at Sandvik's 2018 Annual General Meeting.

"It's a great honour for us. Words can't describe the feeling of being chosen for this year's Wilhelm Haglund Medal, but unreality and pride are closest to hand, given the high level of the other nominated products," stated Emmanuelle Göthelid. "This recognition highlights the importance of material and process development along with systematic work in grade development for success in metal cutting."

The cemented carbide grade that led to the win for Göthelid and her colleagues is known as GC 1130 and was developed for steel milling. The GC 1130 uses a fine-grained cemented carbide with a high content of chrome together with a layer made with Zertivo™, Sandvik's unique production technology for PVD (Physical Vapour Deposition) grades.

The technology enables increased control over the manufacturing process, which is then carefully adapted to the grade-specific requirements. The result is a more stable product with longer cutting life.

"Innovation and constant product development are crucial for our continued success. The fact that GC 1130 is about to be the best selling cemented carbide grade in Sandvik Coromant's product family for mills is a tangible example of the link between investments in innovation and business benefits," added Sandvik's President and CEO Björn Rosengren.

Award winners Emmanuelle Göthelid, Karin Andersson, Marie Pettersson and Björn Ericsson together with Björn Rosengren, President and CEO, Sandvik AB

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GKN showcases demonstrator system for residential hydrogen storage

GKN Powder Metallurgy originally announced plans to develop an innovative hydrogen storage system for residential homes using solid state metal hydride in August 2017. Since then, engineers at the company have developed the demonstrator system, overcoming several technical challenges to adapt sizes and capacity of the required modules.

The objective of GKN's research project is to provide an integrated zero emission heat and energy storage system for an off-grid alpine chalet. Engineers are reported to have aimed for a system capacity of over 130 kW, equivalent to providing a normal four-person household for around twelve to fourteen days with electrical power and no recharging.

The storage challenge

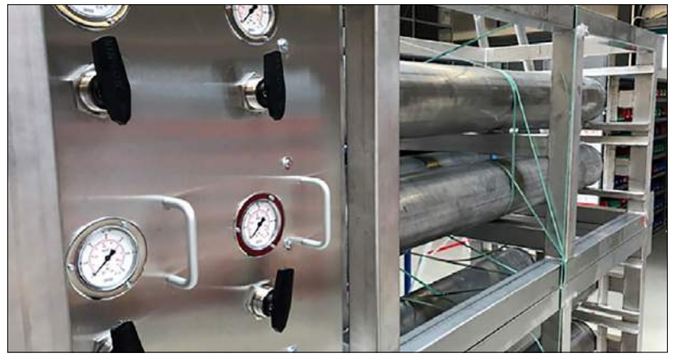
Bringing the concept from a lab-based model to a full-scale system brought the challenge of scaling the system concept and developing new designs for the hydrogen storage tanks.

Typically, hydrogen is stored as gas and requires very large storage tanks operated at high pressure up to 300 bars. Using metal powder as a medium to store hydrogen has some obvious benefits: the same amount of hydrogen gas can be stored in a tank not even half the size compared to gas. Additionally, the metal powder based process works at a lower pressure and is easier to control in terms of temperature levels.

In GKN's process, the storage tanks are loaded with hydrogen gas at pressure levels below 40 bars. The pelletised metal alloy inside the tank reacts with hydrogen and builds metal hydrides. Loading the tank with hydrogen is an exothermic process, meaning the absorption of hydrogen into the metal framework of the tank needs to be cooled and maintained at 20°C to keep the loading process stable and efficient.

For the unloading or desorption, the tank needs to be heated up to 60°C as the chemical reaction to remove hydrogen out of the metal lattice is endotherm. The higher the flow of hydrogen into or out of the tank, the more intensive is the chemical reaction. To increase the kinetic capacity for quick loading and unloading and for safety reasons, thermal management is a key aspect of the metal hydride-tank-system.

"Our engineers have worked on double tube tanks to achieve an optimal heat transfer between the active material and the cooling/heating media. The new tank design speeds up processes and reduces energy losses for heating and cooling, and has also improved and shortened the process to activate the metal pellets to enable the metal hydride process" stated GKN Marketing Manager Ralf Radschun.



GKN Powder Metallurgy's storage module consists of eight separately controlled storage tanks and can store 133 kWh electric power

The electrolyser challenge

Another important aspect was said to be the development of an electrolyser unit, suitable in size for a residential application, to deliver high quality hydrogen gas. Electrolysers available on the market are for applications with high electrical power (usually from 50 kilo watts to several mega watts). "A huge number of modifications were necessary to downsize the electrolyser for our requirements and electrical capacity range of 5 kW. Additionally, much effort was spent to achieve the high gas quality that is required to enable hydrogen storage in metal hydrides," added Radschun. "Working together with our electrolyser partner iGas, a complex hydrogen purification system was developed to achieve a gas quality of 99.999%."

The efficiency challenge

A third requirement is to gain back electrical power from the stored hydrogen and to use the heat resulting from the transformation process. Managing and using the resulting process heat is the important second element that ensures the high round-trip energy efficiency of GKN Powder Metallurgy's concept.

"The unloading and transformation of hydrogen gas back to electrical power works through a proton exchange membrane fuel cell which is the third key module of our system. Developing a clever and reliable control scheme creates efficient heat, power and hydrogen management," added Radschun.

"GKN Powder Metallurgy is on the way to utilising a well-known chemical process and material capability of metal hydride and bringing it to a new level for a real-life residential application. This will help reduce CO_2 levels and bring the opportunity to better utilise natural non-carbon energy sources like wind, water and sun," Radschun concluded.

www.gkn.com

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Haval breaks ground on new Chongqing automotive factory

Haval, the SUV brand of China's Great Wall Motors Company, has broken ground on a new automotive factory in Yangchuan, Chongqing province, China. The new factory is said to be the result of a $1 billion investment and will be based on the company's Xushui, Baoding facility, which is said to feature state-of-the-art equipment including the latest assembly and automated production technology.

The factory is expected to begin production in late 2019, with an initial production capacity of 250,000 units. Haval states Yangchuan was chosen over twenty other potential sites due to its strategic transportation and logistical links in China's south-west region, with access to the Yangtze River and major rail links.

The Chongqing province is China's largest automotive manufacturing hub, giving Haval access to skilled automotive workers and suppliers. The new factory is expected to provide employment for around 10,000 staff.

www.haval-global.com

Makin Metal Powders appoints Magnum Metals its North American sales agent

Makin Metal Powders (UK) Ltd., Rochdale, UK, has appointed Magnum Metals, Nettleton, Mississippi, USA, as its North American sales agent.

Magnum's lead salesman Barry Anshutz is said to have a long track record in the metal powder industry, having previously served as Vice President of Sales for Makin's former sister company, United States Bronze Powders, Inc.

Steve Ellis, Director of Supply Chain Operations at Makin, stated, "Magnum Metals has a first-class team and I am delighted they have agreed to represent us in the North American region. We look forward to working alongside them, utilising their significant market knowledge and excellent relationships, in order to offer our customers enhanced service and responsiveness whilst making the products and expertise of Makin even more accessible in this growing and important market."

Makin Metal Powders manufactures copper powder, bronze powder, tin powder, infiltrants and press-ready pre-mix powders along with other related alloys from its purpose-built 10,000m^2 production facility in Rochdale. The company is one of the largest European producers of copper and copper alloy powders and, as part of the GRINM family of companies, has a global reach with a worldwide network of agents and distributors.

www.makin-metals.com
www.magnum-metals.net

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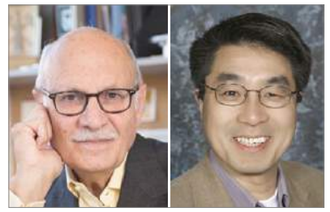
Apelian and Fang inducted into USA's National Academy of Inventors

Diran Apelian, Alcoa-Howmet Professor of Mechanical Engineering at Worcester Polytechnic Institute (WPI) and the founding director of WPI's Metal Processing Institute, and Zhigang Z Fang, Professor, University of Utah, have been inducted into the USA's National Academy of Inventors (NAI).

The NAI inducted 155 Fellows to its 2017 class, and now represents 912 in total, from over 250 research universities, and governmental and non-profit research institutes. Election to NAI Fellow status is considered one of the highest professional accolades which can be bestowed upon academic inventors, and is said to recognise "a prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development and welfare of society."

Professor Diran Apelian is widely recognised for his innovative work in metal processing and for his leadership as a researcher and educator. His research is said to have helped establish mechanisms and fundamentals in metal processing and laid the foundations for significant industrial developments. More recently, he has been involved in the development of technologies to recover and recycle materials.

Since 2002, Professor Zhigang Z Fang is said to have developed externally funded research programmes in the areas of nanopowder synthesis, nano sintering, functionally graded hard metals, Powder Metallurgy titanium, intermetallic coatings and hydrogen storage materials. He has authored and co-authored over 120 publications, including technical articles, and over thirty US patents.



Diran Apelian, Alcoa-Howmet Professor of Mechanical Engineering at Worcester Polytechnic Institute (left) and Zhigang Z Fang, Professor, University of Utah (right) (Courtesy Worcester Polytechnic Institute & University of Utah)

"I am incredibly proud to welcome our 2017 Fellows to the Academy," commented NAI President Paul Sanberg. "These accomplished individuals represent the pinnacle of achievement at the intersection of academia and invention— their discoveries have changed the way we view the world."

www.academyofinventors.org

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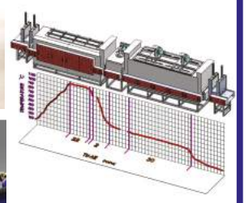

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Expansion at Atlas Pressed Metals with addition of two new compaction presses

Atlas Pressed Metals has installed two additional compaction presses at its manufacturing facility in DuBois, Pennsylvania, USA. The Powder Metallurgy parts maker has installed a new 175 ton CNC fully hydraulic Osterwalder press and a Gasbarre 100 ton die set press with two lower and two upper punch capability.

The Osterwalder CA/NC 1600 will provide the ability to manufacture components of up to seven levels at the Atlas plant. The Gasbarre 100 ton die-set press will help to expand current manufacturing capacity while filling a role between Atlas' 60 ton and 150 ton business.

Atlas manufactures Powder Metallurgy components for the automotive, appliance, lawn and garden, controls, electric motors and hand tools industries. The company stated that it invested in the seven-level press to expand its capabilities in complex structural parts.

During the compaction process each 'level' of the part is separately supported by its own punch or set of punches. The hydraulic action can move the powder into place at each level prior to compaction. This added powder transfer capability, combined with a four levels down, three levels up press, renders the new unit extremely versatile in forming complex parts with more uniformity in density throughout the part, the company stated.

Joe Pfingstler, Technical Sales Manager, Atlas Pressed Metals, explained that in standard action mechanical and die set presses, the tooling movement is tied to the speed and position of the cam as it rotates. "Standard mechanical pressing works well for many components, but there are applications that it can limit the ability to quickly make adjustments, or might otherwise require tooling modifications to produce a finished component," he stated.

"The combination of CNC and hydraulics allows for independent movement of tooling levels," he continued. "By freeing the tool from the rotational position of the press cam, each tooling level can move as needed in both direction and speed. This freedom provides the ability to fill, position the material, compact and eject the finished component more effectively."

The Osterwalder press also features a tool deflection monitoring system, to allow the die setter to adjust for tool deflection that may develop within the stroke cycle, rather than making adjustments or accepting variations caused by the tool deflection. The computerised press further monitors and records tonnage per job and other press data features, which can easily be accessed for traceability as needed. Pfingstler noted this feature is an extension of Atlas' current data collection system.

With the presses installed and now running, manufacturing floor space at Atlas Pressed Metals is near capacity. Atlas stated it will soon be releasing details on a new expansion at the plant.

www.atlaspressedmetals.com

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Höganäs reveals the results of its first annual sustainability report

Sweden's Höganäs AB has released details of its first annual sustainability report, which will now be issued once a year according to new EU requirements. The company signed the UN Global Compact in 2017 and states that it has applied its ten principles to increase sustainability across the organisation.

In 2017, the report stated that 77% of the company's process-related residual materials were reused or found a new use. The company also reported a 7.1% reduction in energy use per produced tonne of metal powder within its direct operations since 2010. In addition, water used by the company recirculated an average number of sixteen times before becoming wastewater.

Fredrik Emilson, Höganäs President and CEO, stated that in 2017, "Höganäs's sustainability work continued with deeper integration of sustainability as an aspect of the business strategy and planning process. Increasingly, sustainability is seen as a natural part of discussions and development projects throughout the company."

"Our main focus areas are to reduce our climate and environmental impact; responsible sourcing and use of materials for production; and offering a safe and meaningful workplace," he continued. "We do this by responsibly producing resource-efficient products that benefit both our customers and society."

"In late 2017 we took an important step away from fossil fuels and towards renewable energy," he added. "In Höganäs, Sweden, we broke ground for a plant for production of renewable energy gas and green coke. The goal is to transform biomass into renewable energy, and prove the technology so it can be used widely in the iron and steel industry."

In addition to signing the UN Global Compact and moving to eliminate its use of fossil fuels, Höganäs stated that it has implemented a tool for reporting group-wide sustainability data and key performance indicators, and that it conducted a pilot project for a supplier evaluation tool.

"We will continue to work with sustainability at a high pace during 2018," Emilson added. "We plan to update our Code of Conduct, launch the supplier evaluation tool for our suppliers of direct material, continue work on the climate roadmap, and establish a partnership with Plan International concerning water purification technology in countries in great need of support."

www.hoganas.com

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UK researchers halve cost of titanium part production

Researchers from the UK Ministry of Defence (MoD)'s Defence Science and Technology Laboratory (Dstl) in Porton Down, Wiltshire, UK, and the University of Sheffield's Department of Materials Science and Engineering, Sheffield, Yorkshire, UK, state that they have dramatically reduced the cost and difficulty of titanium part production by reducing the typically lengthy process down to just two steps.

Titanium's high strength, light weight and corrosion resistance sees it widely used in the defence industry, such as in military aircraft and submarines, but the high production costs associated with the material have reportedly made it difficult to justify its use in all but the most essential areas. According to Dstl, the new reduced-step process has the potential to cut the cost of titanium parts by up to 50%.

Dstl states that it has invested almost £30,000 in the new research project at the University of Sheffield, which led to the development of the new ground-breaking manufacturing process, named FAST-forge. Working with Dstl and Kennametal Manufacturing (UK) Ltd, Sheffield's researchers developed a hybrid manufacturing processing technology which consolidates titanium powder, including machined swarf, into a bulk material in two solid-state steps.

The powder can then be shaped close to the desired component without the need for numerous expensive and process-limiting thermomechanical steps. Dr Nick Weston, from the Department of Materials Science and Engineering, explained, "FAST-forge is a disruptive technology that enables near-net shape components to be produced from powder or particulate in two simple processing steps."

"Such components have mechanical properties equivalent to forged products. For titanium alloys, FAST-forge will provide a step change in the cost of components, allowing use in automotive applications such as powertrain and suspension systems."

Gavin Williamson, the UK's Defence Secretary, stated, "Our Armed Forces use titanium in everything from cutting-edge nuclear submarines and fighter jets through to life-changing replacement limbs – but production time and costs mean we haven't always used it. This ground-breaking method is not only faster and cheaper but could see a huge expansion of titanium parts and equipment throughout the military."

So far, small-scale trials of the new production process have been carried out, but a new large-scale fast furnace facility jointly funded by Dstl and Kennametal UK has been built and is expected to enable larger components to be produced for testing.

Matthew Lunt, Principal Scientist for Materials Science at Dstl, commented, "We're really excited about this innovation, which could cut the production cost of titanium parts by up to 50%. With this reduction in cost, we could use titanium in submarines, where corrosion resistance would extend the life, or for light-weight requirements like armoured vehicles."

www.gov.uk
www.sheffield.ac.uk
www.kennametal.com

Rickinson to retire from UK's Institute of Materials

Dr Bernie Rickinson, Chief Executive of the UK's Institute of Materials, Minerals and Mining (IOM³), has announced he will retire from his role with the Institute at the end of 2018. As yet no successor has been announced, but IOM³ confirmed that recruitment consultants have been engaged.

Rickinson became Chief Executive in 1997 and has since guided the organisation to its current position as a major UK engineering institution whose activities encompass the whole materials cycle, from exploration and extraction, through characterisation, processing, forming, finishing and application, to product recycling and land reuse.

IOM³ was formed from the merger of the Institute of Materials and the Institution of Mining and Metallurgy in June 2002. It merged with the Institute of Packaging (2006) and the Institute of Clay Technology (2006). In the Summer of 2009, the Institute reached an agreement with the Institute of Wood Science to transfer all its members and activities to IOM³. In November 2010, IOM³ also embraced the activities and membership of the Institute of Vitreous Enamellers.

Commenting on his retirement, Rickinson advised that with the organisation's 150th anniversary set for 2019, it will be important for a new Chief Executive to take full advantage of the opportunity for community visibility during the series of anniversary events planned by the Institute.

Dr Bernie Rickinson, Chief Executive of the UK's Institute of Materials (Courtesy IOM³)

IOM³ stated that it would like to "sincerely thank Bernie for his outstanding contribution to the Institute and to the engineering community throughout his twenty years of service."

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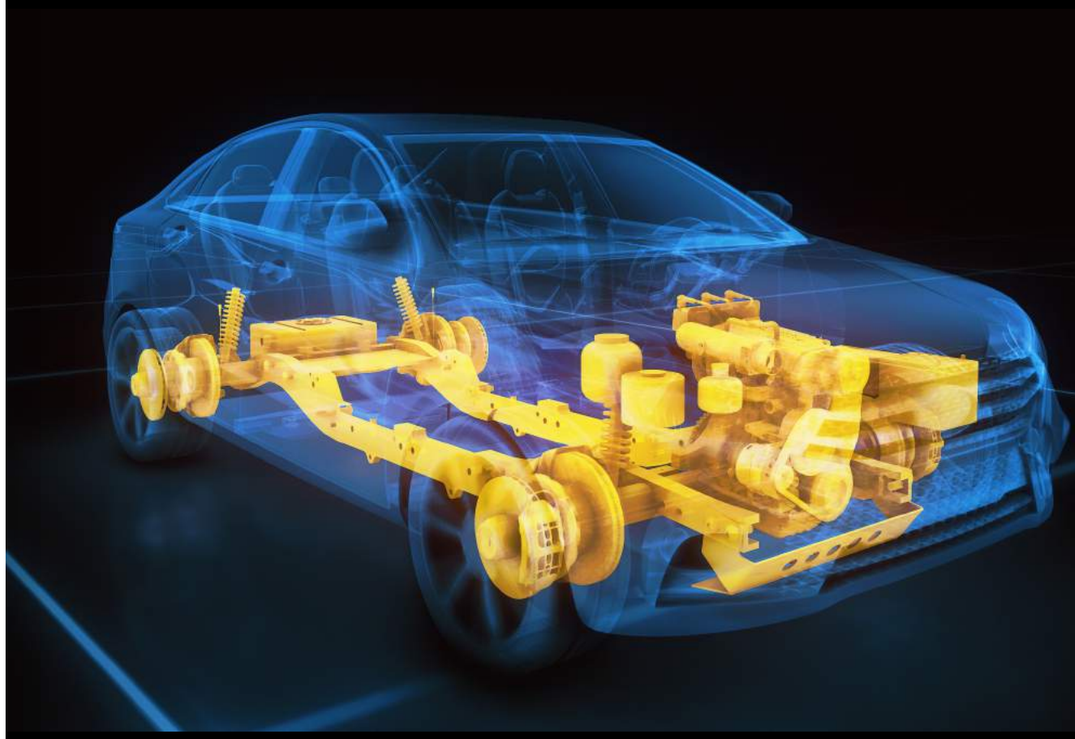

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European Powder Metallurgy Association's 31st General Assembly

The European Powder Metallurgy Association's 31st General Assembly recently took place in Brussels, Belgium, March 22-23. The two-day event included Board, Council and Committee meetings, as well as meetings of its EuroMIM, EuroPress&Sinter and EuroHIP sectoral groups. The EPMA's Annual Dinner took place at Brasserie Mundy.

Two invited keynote presentations enhancing the programme were provided by Guy Thiran, Director General of Eurometaux on the topic of 'Legislation and Lobbying', and Sigrid de Vries, Secretary General of CLEPA (European Association of Automotive Suppliers) on the subject of 'The Future of the Automotive Supply Industry'.

Thiran centred his presentation around the activities of Eurometaux and how they provide lobbying activities on the various metal sectors to the various EU parliamentary bodies, looking at how EPMA members can benefit from this activity.

The presentation by de Vries reviewed the state of the automotive industry and highlighted future threats and opportunities that may lie ahead for the Powder Metallurgy supply chain sector.

The EPMA has made a number of the General Assembly and Sectoral Group presentations available for download. Video footage of the presentations will also be made available via the EPMA's YouTube Channel.

www.epma.com

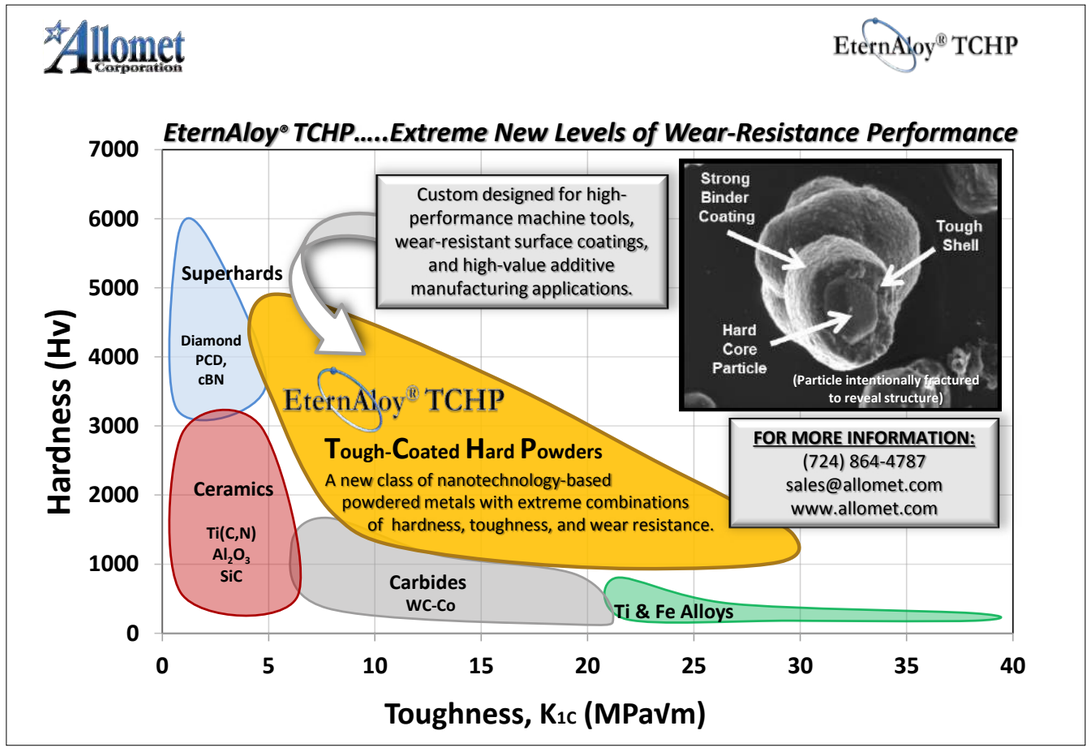
MPIF's Basic PM Short Course announced

The Metal Powder Industries Federation's Basic Powder Metallurgy short course will be held at the Penn Stater Conference Center Hotel, State College, Pennsylvania, USA, from August 13-15, 2018. Early-bird registration for the three day course course will close on July 13, 2018.

Now in its fifty-fourth year, the course offers a complete introduction to Powder Metallurgy from powder production to component design and standards. As well as press and sinter PM, processes covered include Metal Injection Moulding and Additive Manufacturing.

The intensive course is designed for anyone who is either new to the PM industry or looking to broaden their knowledge of the technology.

www.mpif.org



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International Symposium on Novel and Nano Materials heads to Lisbon

ISNNM 2018 is taking place at the Tivoli Oriente Hotel in Lisbon, Portugal

The 15th International Symposium on Novel and Nano Materials (ISNNM) is set to take place in Lisbon, Portugal, July 1-6, 2018. Organised by the Korean Powder Metallurgy Institute, the event will include three days of conference sessions followed by technical tours and panel discussions.

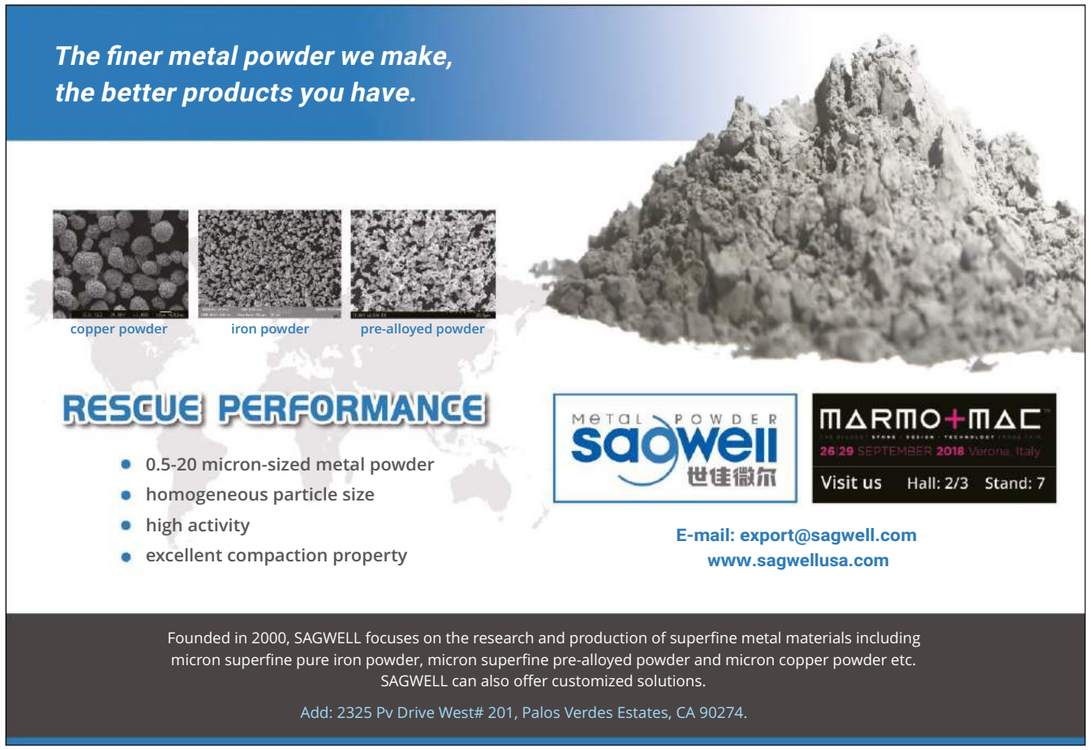
ISNNM will focus on nanomaterials research, and will include sessions on:

- Advanced Materials Processing
- Novel Functional Materials
- Advanced Powder Metallurgy
- Mechanical Alloying
- MIM and Additive Manufacturing
- Nanocomposites and Nanoporous Materials
- Energy Materials
- Rare Earth & Recycling
- Refractory Metals & Hard Materials
- Characterisation & Modelling

All main aspects of the materials will be covered, including synthesis, mechanism, microstructures, properties and applications.

The symposium will provide the latest research results and a state-of-the-art overview of technology in the rapidly evolving field of nanomaterials. Symposium sessions will also include invited lectures from internationally distinguished scientists, discussing topics ranging from the most recent discovered materials to the latest techniques of production.

www.isnnm.org



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University of Louisville team examines use of Additive Manufacturing in development of PM components

As part of the University of Louisville's 3D Printing Business Incubator, a total of twenty start-up teams, comprising nearly one hundred mechanical engineering students, were trained and educated in techno-economic aspects of Additive Manufacturing. Harish Irrinki, at the university's Materials Innovation Guild, reports that during the nine month pilot project, students worked with academia and industry partners on various case studies that examined the feasibility of using AM in industries that are served by alternative manufacturing. The goal was to identify opportunities for decreasing lead time and cost, as well as incorporating performance improvement in new designs.

Powder Metallurgy is a proven net-shaping process for the high-volume fabrication of precision parts for a broad range of transportation, medical, electronics, industrial and consumer applications. However, the growth of applications and market size depends to a large extent on design engineers being familiar with the technology when prescribing parts based on processing metal powders. The advent of metal Additive Manufacturing provides an opportunity for design engineers to become acquainted with Powder Metallurgy at an early stage of their education and training, and the University of Louisville has been active in addressing this over the last year.

The lead time to translate a new product design into manufacturing can be time-consuming and expensive. In the design cycle, for example, various stages involve physical prototypes created to test and validate the design. Implementing Additive Manufacturing in the design cycle of a new product could be one option to improve this process. However, understanding the material-process-properties relationship is one barrier to wider adoption of AM to complement and integrate with traditional processes.

The research, performed at the University of Louisville's Materials Innovation Guild, focuses on obtaining a fundamental understanding of AM process characteristics, material properties and microstructure through an integration of carefully designed experiments to enable optimisation of the materials-design-process relationship. With an understanding of these relationships, an opportunity could emerge that enables new design innovations and products in a range of industries.

Automotive engine gears

The automotive industry is constantly driving towards a shorter time-to-market for its new products. This has influence on suppliers, such as gearbox manufacturers, who must design and test products in a much shorter period. A critical aspect of this process is the lengthy lead time (40 weeks) required to create new gear prototypes, mostly caused by the need to develop tooling for die compaction. This long lead time limits the number of designs which can be tested and makes it difficult to achieve the best tribological and acoustic performance.

For this reason, gearbox manufacturers could benefit from technologies such as Additive Manufacturing to create precision gears for prototyping purposes. In this regard,

Fig. 1 The Bluegrass Engineering Solutions student start-up team that worked on the automobile engine gear: Austin Anderson, Brad Gootee, Michael Kjelby, Devon Warman, Gunnar Wagoner (Courtesy University of Louisville)

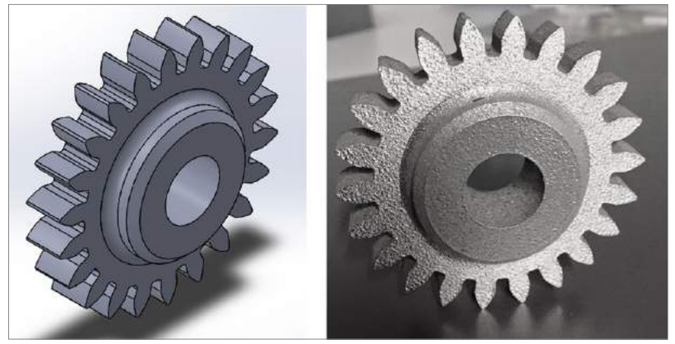

Fig. 2 Automotive engine gear redesigned and produced by L-PBF (Courtesy University of Louisville)

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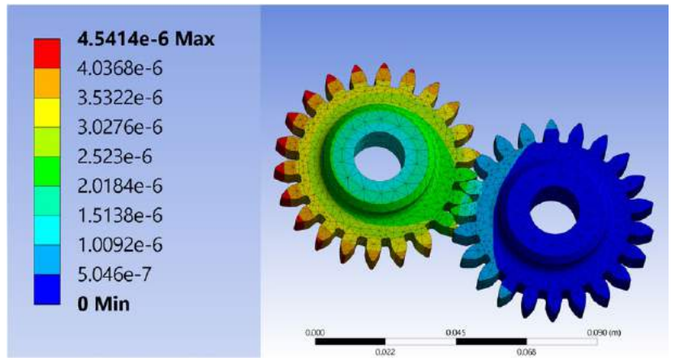

Fig. 3 Distortion analysis of gears using ANSYS software (Courtesy University of Louisville)

Dimension	AM part (mm)	PM part (mm)	CAD model (mm)
Tooth thickness	9.75	9.8	9.8
Overall diameter	64.5	64.5	64.6
Base diameter	49.5	49.58	49.5
Overall gear thickness	16.5	16.6	16.8
Shaft diameter	15.8	16	16

Table 1 Comparison of dimensions of AM and PM gears with CAD model (Courtesy University of Louisville)

a student start-up team at the University of Louisville, Bluegrass Engineering Solutions (Fig. 1), worked with an automobile engine manufacturer with the aim of decreasing the lead time to produce gear prototypes using AM (Fig. 2).

A primary challenge for design engineers when choosing a prototype production method for a specific product, such as automotive engine gears, depends on batch size and production cost. The economic batch size and cost analysis of the Laser Powder-Bed Fusion (L-PBF) AM process was performed using CES Edupack and this showed that the L-PBF process offers a cost-effective and efficient option for a low volume production process. The gear geometry was then designed using commercially available CAD software and initial strength verification was performed using FEM techniques (ANSYS software) (Fig. 3). The prototype gear was fabricated using an EOS M 290 machine from 17-4 PH stainless steel powder, chosen because of its high strength and corrosion resistance. 17-4 PH is widely used in automotive, medical and aerospace industries.

Geometric analysis on the AM gear and PM gear was performed and results are shown in Table 1. The geometric dimensions of the AM gear were comparable to the gear manufactured by PM. However, to test the function of the AM gear would require additional surface finishing such as machining. Through time and cost analysis, it is estimated that using AM in the design phase could reduce the prototyping costs by 50% and design cycle time by 90%, compared to the current methods used by the engine manufacturer.

Summary and future outlook

This study demonstrates a method for decreasing the time to market for a number of components in the automobile industry. Future work includes working with alloys specific to PM using binder jetting, as well as incorporating functional features such as weight reduction and noise reduction. Further testing of the gear will be performed using a test setup at the automotive engine manufacturer's facility to validate the AM part.

Further, the academic programme strongly suggests a pathway for PM industries to benefit from new products as well as fresh engineering talent. Efforts are underway to scale the programme to achieve a regional economic impact in the form of an industry-government-academia collaboration.

Acknowledgment

The author would like to thank the Walmart Foundation, Mechanical Engineering Department at the University of Louisville as well as industries that supported the projects presented in this paper (Amaray, Concept Laser, Cummins). Further, funding was provided by the National Science Foundation for supporting the prototype fabrication and the LaunchIT entrepreneurial training at the Nucleus. The students greatly benefitted from a 10-week minimum viable product development and customer discovery training conducted by Mary Tapolsky, Mark Crane, Ty Adams, Lisa Bajorinas, and Suzanne Bergmeister.

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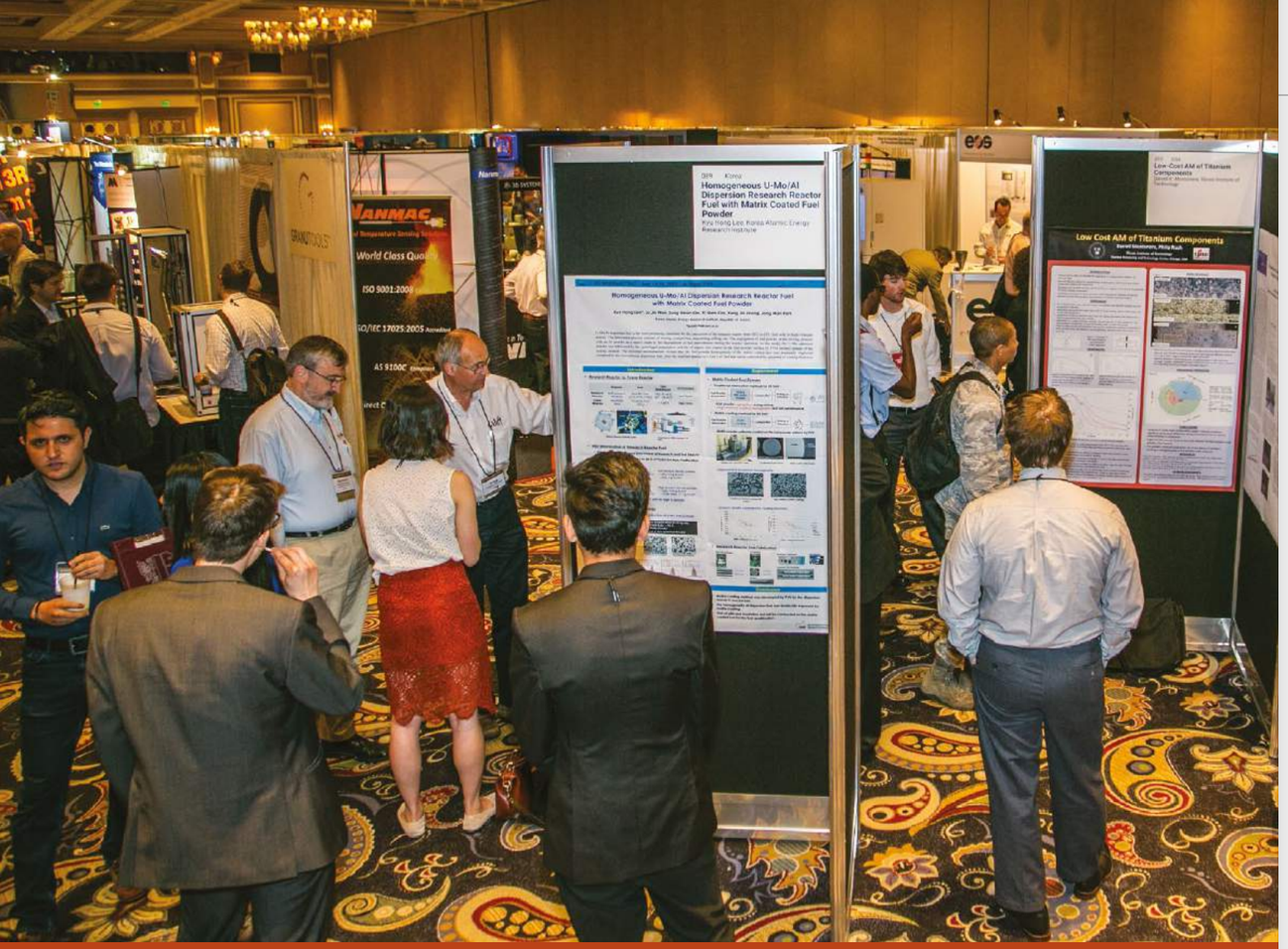

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Metal Powder Industries Federation: Education and technology promotion is key to PM's future

The Metal Powder Industries Federation was established to represent and promote the North American Powder Metallurgy industry. Serving members in all sectors of the supply chain, the work of the MPIF is recognised globally, not only for its development of industry standards, but also for its continuous promotion of metal powder based technologies to end-user sectors. Jim Adams has been Executive Director of the MPIF since early 2017 and in this exclusive interview we highlight the work of the MPIF and share his unique perspective of the North American PM industry.

The MPIF traces its roots to the closing days of World War II, when a group of entrepreneurs, engaged in the still fledgling industry involved in making parts from metal powder, were faced with a looming crisis. With the end of the war, the industry - which until then had consisted primarily of self-lubricating bearings - would be saddled with a severe surplus production capacity that had been geared up for the war effort. The only answer would be to expand existing markets and develop new ones, helped by what was to become a period of economic boom as servicemen returned home to resume life as consumers.

The group decided that it must act to promote the technology to a then sceptical engineering community. The decision was made to develop the standards and testing methods that customers would demand and to obtain crucial and reliable statistical data about the vitality of the industry and its future prospects. The industry would also need to set aside any differences and speak with a single voice. The decision was made; they would form a trade association.

On May 4-5, 1944, New York City's Waldorf-Astoria hotel held the first meeting of the Metal Powder Association, predecessor to today's Metal Powder Industries Federation (MPIF). The early meetings were tacked on to the prominent Lead

Fig. 1 The MPIF and APMI bring the global Powder Metallurgy industry together during the annual POWDERMET conference and exhibition

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Fig. 2 Back row, left to right: Stacy Kalokitis, Systems Administrator, Diane Haggerty, Director, Events, Exhibits & Advertising, Turner Abbott, Manager, Office & Technical Services, Sherry Henry, Administrative Accounting, Stephanie Schember, Administrative Registration & Membership, Paul Sedor, VP, Member and Industry Relations, Lisa Lester, Communications Director, Debby Stab, Communications Manager. Seated front row from left to right: Dora Schember, Manager, Member Services & Standards, Jill Regan, VP, Finance and Administration, Jim Adams, Executive Director/ CEO, Tessa Stillman, Senior Manager, Standards and Technical Services

Industries Association meetings until 1956, when Kempton H Roll was appointed MPIF Executive Director.

True to its charter, the MPIF issued its first standard, Std. 01 Method for Sampling Metal Powders, in 1945. To this day, it continues to collect statistical data, such as North American iron powder shipments, which provide the best barometer for the health of the regions PM industry.

Over the years, the MPIF has remained the voice of the North American PM industry, while working closely with its Asian and European equivalents. Its annual POWDERMET conference is recognised by attendees as one of the best organised manufacturing conferences in North America.

What began as a single association embracing all the diverse players involved in the industry eventually evolved into a federation serving as an umbrella organisation over six different associations, each representing a distinct segment of the industry (Table 1). With the six federated associations, the MPIF represents over 250 member companies. In addition to this, the MPIF also offers other membership types for interested companies which are not eligible for membership in the above associations, as well as for PM industry consultants.

Metal Powder Industries Federation

PMPA	MPPA	PMEA	MIMA	RMA	AMAM
Powder Metallurgy Parts Association	**Metal Powder Producers Association**	**Powder Metallurgy Equipment Association**	**Metal Injection Molding Association**	**Refractory Metals Association**	**Association for Metal Additive Manufacturing**
Members manufacture a broad range of parts fabricated by press and sinter technologies	Manufacturers of metal powders used in the production of PM parts	Suppliers of tools and dies, compacting presses, sintering furnaces, atmospheres, handling and impregnation equipment, and other equipment and services used in the PM process	Producers of metal powders, feedstocks, moulds, moulding machines and sintering furnaces for MIM applications	Serving to promote and expand the market for refractory metals	Manufacturers of AM parts, powders, equipment and those who provide services to support the AM industry

Table 1 The MPIF consists of six trade associations

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The MPIF relocated from New York City to Princeton, New Jersey, in 1973. Currently, it has a staff of twelve (Fig. 2) and, over its nearly 75-year history, it has only had four Executive Directors.

APMI International

With the success of the company-membership driven MPIF, a need surfaced for individuals that had an interest in PM, but were not necessarily employed by an MPIF member company. The MPIF, therefore, founded the American Powder Metallurgy Institute, today's APMI International, in 1959 to serve the needs of individuals working in the Powder Metallurgy industry.

APMI's goal is to help employees of all industry companies to acquire an ever-growing body of technical knowledge, which ultimately uplifts the industry as a whole. Administered by the same staff as the MPIF, APMI has grown to become a highly respected professional society which has helped advance the science and practice of Powder Metallurgy. Its quarterly *International Journal of Powder Metallurgy* is one of the most recognised PM journals globally, and the annual *Who's Who in PM* directory is a staple for all PM professionals.

Fig. 3 The MPIF organises a wide range of events including conferences, seminars, short courses and exhibitions

Jim Adams, MPIF Executive Director/CEO

Jim Adams began working for the MPIF in 2004, following almost twenty years in the Powder Metallurgy industry. His career began as a lab technician and process engineer for American Powdered Metals Company in Connecticut and North Carolina (now GKN Sinter Metals Conover). He later became a supervisor in the Powder Metallurgy and heat treatment departments at Trico Technologies Inc., Texas, and then worked as a sales manager at both Greenback Industries, Inc., Tennessee, and Kobelco Metal Powder Sales, Michigan. Over the years, Adams developed a thorough understanding of the PM process and came to know a high percentage of the 'movers and shakers' in the PM industry.

"In 2004 I was looking for a career change within the PM industry. I had worked on the annual MPIF conference programme committees since 1995 and had a good relationship with several staff members," Adams told *PM Review*. "I also had great knowledge of the APMI, as I joined in 1983 as a student whilst at Hennepin Technical College, and was also active in the APMI Southeast Chapter as its Chairman. I decided that my career experiences would be best utilised by sharing with the greater PM industry."

Adams joined as Director, Technical Services at the MPIF and, over the last fourteen years, has also administered the activities of the APMI, the Center for Powder Metallurgy Technologies (CPMT) and several of the federated trade associations.

"After joining the MPIF, it was apparent that we were entering an exciting time that would require change if the MPIF and APMI were to continue to service the industry properly. The European Powder Metallurgy Association (EPMA), Japan Powder Metallurgy Associaiton (JPMA) and MPIF were about to launch the Global PM Property Database. What a great example of world regions working together for a greater cause. MPIF launched new marketing campaigns and a new website with PickPM.com; assumed organisation of the annual MIM conferences; moved to digital publications and on-demand printing; and reduced the staff size through attrition."

During this time APMI was going through financial problems due to a decline in membership, as witnessed in many professional societies. "Difficult decisions were made, such as reducing what was once 18 chapters into one and returning the *International Journal of Powder Metallurgy* to a quarterly journal. But the results

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were positive and APMI is back on strong footing," Adams added.

Having experience of both the PM industry and the running of an international PM trade association made Adams the obvious choice to lead the organisation when C James Trombino announced his retirement in 2016. In February 2017, Adams was appointed Executive Director and CEO. "Today, the MPIF and APMI are healthy. We continue to provide what we consider to be the best technical conferences in North America. We are about to launch the MPIF Digital Library, a searchable database of past conference technical papers dating back to 1945 that can be downloaded for review. We are convinced that early research and development exists that maybe couldn't be commercially developed at the time, but with today's equipment, it could be moved from the lab to production."

Committed to developing industry leading standards

The MPIF actively works in the development and creation of industry standards and has had a standards development programme since issuing its first standard in 1945.

"Standards are a core objective to build legitimacy and value to grow the PM industry. The objective is to eliminate misunderstandings between manufacturer and purchaser; facilitate interchangeability and improvement of products; assist the purchaser in selecting the proper material for the product; and to not limit manufacturing or selling products not conforming to such standards."

The standards are developed by the industry, for the industry, and are based on the commercial manufacturing process. "The MPIF membership takes standardisation seriously. Over $125,000 is budgeted annually to operate the MPIF standards programme, with some matching funds from CPMT for strain-controlled low-cycle fatigue testing." Strain-controlled low-cycle fatigue properties are requested by the North American automobile industry for their FEA models.

All standards are affirmed by the membership and both negative and other affirmative technical comments are fully addressed in the ballot adjudication process. The MPIF has a close relationship with ASTM International, as they use a similar approval process, and both groups work to achieve harmonisation so that ASTM and MPIF standards 'speak the same language', a huge plus for any user. The ISO approval process differs in that each participating country, not company, receives one vote, and for the most part ISO PM standards have been converted into European Standards (EN) through the European Committee for Standardisation (CEN).

"One major difference is that the MPIF is able to expedite materials standards development through its working groups with funding, a luxury that many standards development organisations don't have. I estimate that over $2,000,000 has been budgeted for PM standards development since I joined the MPIF. And I suspect that figure can easily be doubled when you factor in 'in-kind' contribution by industry personnel and their active support and participation in standards development activities - that's a pretty remarkable figure! I don't think ASTM or ISO can make that statement."

Regarding the future, Adams added that any standards development programme will continue to be challenged to seek common ground, expand joint efforts or relinquish duplicity of effort where it makes good common and financial sense to do so. However, any such efforts must continue to recognise differences in local practice and use of the technology. "By doing so, the overall continued advancement of PM technology on a global basis and the well-being of its industry's customers can be assured," he added.

Fig. 4 Development of industry standards is vital to the success of any industry, and the MPIF has been instrumental in creating globally accepted standards in all areas of PM technology

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Fig. 5 The automotive industry consumes around 73% of all Powder Metallurgy products in North America. Shown here is just a small selection of MPIF 2017 award winning parts for automotive applications

Challenges in the automotive market

Traditional markets for PM are being threatened across the world, as the automotive industry is forced to move away from large internal combustion engines (ICEs) to smaller power units and alternative energy sources. "One of my greatest concerns is the reduction in size and possible elimination of the internal combustion engine, as the automotive industry consumes about 73% of all PM products in North America," Adams stated.

The North American automotive market is, however, different to that of Europe and Asia. According to US passenger vehicle sales, preferences started to change around 1997 with a move from sedans to sport utility vehicles (SUVs) and light trucks (Fig. 6). The segment is now responsible for over 70% of the US passenger vehicle market and these models today contain an estimated average of 75 lbs (34 kg) of PM parts per vehicle. The continued demand in this sector has resulted in Ford Motor Company recently announcing it was reducing its sedans to just two models, effectively moving more people to SUVs and light trucks. "Great news for the PM industry, as they consume more PM parts in these larger all-wheel and four-wheel drive vehicles!" commented Adams.

However, a move to smaller power units will result in a reduction in the weight of PM parts. Many of these vehicles have eight-cylinder engines, and changing to a six-cylinder or four cylinder turbocharged model would remove at least 4 lbs (2 kg) of PM. "That's at least a 5% reduction in iron powder shipments for our most coveted vehicles," Adams was keen to point out. "I am concerned about the volume of powder decreasing if new applications are not identified. The parts makers will continue to run their presses, manufacturing smaller parts or finding new applications, so they shouldn't feel the squeeze, but the powder producers may be in for some contraction. I believe the North American PM lbs per vehicle will drop 1-2 lbs per year over the next five years before levelling out, provided there are no breakthroughs in electric vehicles."

Hybrid and electric vehicles

Regarding hybrids (HEVs) and electric vehicles (EVs), there are clearly a number of hurdles to cross before full acceptance is attained. According to Adams, HEV and EV models haven't been overly well received in North America. "If people aren't willing to purchase an HEV that comes with a back-up ICE when the

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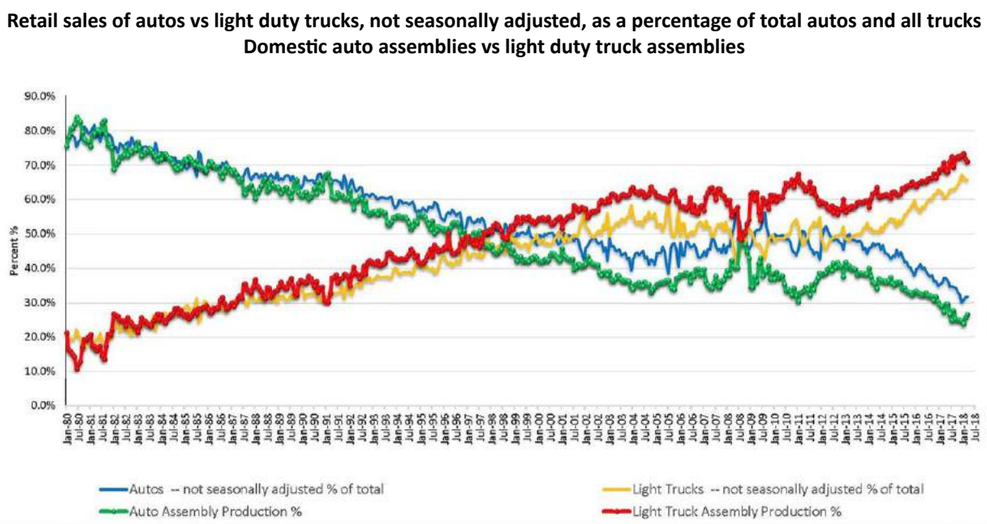

Fig. 6 The North American passenger vehicle market has witnessed a move away from traditional sedan models, preferring larger vehicles in the SUV and light trucks category

electric supply is exhausted, why do we think that they will go for an EV? There are some long commutes in North America that just don't make an EV economical or logical. Until there is a vehicle with a 400 mile charge and an infrastructure to support rapid charging mass amounts of vehicles, we had better not write the ICE off as dead," stated Adams. "I think that the ICE will be the primary power supply for at least the next fifteen years. Will the amount of eight-cylinder vehicles match today's? Highly unlikely. I suspect the four-cylinder will be the norm at that time."

Today at least, it seems that the automotive market for North America's PM parts makers remains buoyant. Adams is of the opinion that the automotive sector will continue to be the largest consumer of press and sinter PM parts by weight for the indefinite future, and the development of new materials and processes will advance growth into new markets. "Interest is still strong and there continue to be new, innovative parts designed each year. Automotive will remain the largest consumer of PM for quite some time. It is amazing when you review the number of applications in the MPIF Automotive Parts Catalogue."

The MPIF is currently bringing its 'PM Showcase' to the North American automotive industry. This is a full-day educational programme with an information booth that is staffed and supported by the membership. "Interestingly enough, at a recent PM Showcase, a powder-forged connecting rod was held up and only about a half-dozen of the seventy-five automotive engineers knew that it was PM. By the end of the day, they were asking about scheduling the next PM Showcase because they realised they could use PM as a lightweight technology while minimising scrap from machining."

Opportunities for Metal Injection Moulding in the automotive sector

Talking of the opportunities for Metal Injection Moulding in this sector, however, Adams is more cautious. "Unfortunately, in North America MIM has the stigma of being an expensive alternative as viewed by the automotive sector. I constantly challenge that misconception. Yes, MIM is more expensive than a stamping, casting, or a press and sinter PM part. If you can use one of those processes to manufacture an acceptable part, it should be less expensive. But, when you use one of those processes and subsequently have to perform extensive machining, or are limited to certain design features, a MIM option can prove the most economical solution. Again, this comes down to educating the customer. There continue to be strong opportunities for all PM technologies if we can continue to educate the customers."

Material and equipment developments

To continue to penetrate existing market sectors and open new opportunities, the PM industry needs to continue to offer new materials and processes. "I think that our industry is challenged to develop new materials and processes to meet the robust requirements of the evolving automotive industry. Higher RPM engines, higher-temperature operating conditions and higher speed transmissions, all in a smaller package, are great opportunities for PM to be the solution," Adams said. "PM has that unique ability to develop alloys that are not economical or possible to manufacture by other methods. Our metal powder producers continue to push the envelope to develop new materials with higher densities, tensile strengths, ductility and fatigue limits in conventional and severe operating temperatures. Equipment manufacturers have implemented smart manufacturing options that allow parts manufacturers to collect data on compacting presses, sintering furnaces and machining centres and control the process through a centralised information centre."

Fig. 7 The MPIF organises a number of technical seminars and training courses each year

Education is more important than ever for the future of PM

Commenting on a recent conversation at an exhibition with two researchers from a prominent North American university, Adams was unsurprised to hear that they couldn't comprehend controlled shrinkage on a MIM part after reviewing green, brown and sintered parts. "Too many times I ask what level of knowledge an engineer has about PM and they say 'liquid metal is poured into a mould' and I let them know that is called casting! We have to continue to educate the consumer."

The MPIF has tried unsuccessfully for years to have a PM curriculum added to the ABET requirements for higher education. "About ten years ago we offered an entire course (twenty-six 45-minute classes with instructor's guide, quizzes and tests) to over fifty universities. Only two professors requested more information, eventually deciding there wouldn't be enough interest from students to take the course." However, there is some light at the end of the tunnel, thanks to Additive Manufacturing. It would be difficult to find a university in North America that doesn't have a 3D printer. "Every month I learn of a new university that is using a metal AM machine."

Fig. 8 Recipients of the NSF Conference Grants at POWDERMET2017

Investing in the next generation of PM specialists

One of the most cited concerns during the annual MPIF PM Industry Pulse Survey for the past five years has been the need for skilled workers. This is not isolated to the PM industry, but is a concern for all industries within North America. Through diligent work, the MPIF was able to have PM recognised by NSF as an advanced manufacturing technology in need of future engineering support. This was the launchpad for receiving funding for students to be exposed to the annual POWDERMET conference through the NSF Conference Grants. "We have been fortunate to have the National Science Foundation provide grants for forty US university students to attend our POWDERMET2017 and POWDERMET2018 conferences (Fig. 8). These grants provide full registration and hotel accommodations for the students, and give them an opportunity to present their research."

Since 1990, CPMT has provided over $140,000 to 109 students through the Axel Madsen Conference Grant programme. It is estimated that over 25% of these students are still connected to the PM industry. "This is a fantastic return on investment and very encouraging when we consider the possibilities that the NSF grant

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Fig. 9 The MPIF showcases the capability of Powder Metallurgy technology through its annual PM Design Excellence Awards

could have for supplying engineers to our industry." Additionally, CPMT has provided over $500,000 to 147 students since 2000, through its Clayton Family Foundation, Howard I Sanderow Endowment, North American Höganäs Co., Ametek, Inc., Western Sintering and University of Idaho scholarships.

The MPIF also offers reduced registration fees for POWDERMET to encourage its members to bring their up-and-coming engineers to the conference, to encourage them to network and be a part of the technology transfer. "I am encouraged when I hear from young engineers that they thought they could get everything that they needed from the internet, but have found that face-to-face meetings have so much more value. We are also seeing new, younger faces at our standards meetings, on our technical programme committees, and as speakers at our conferences. I think, ultimately, we will find the balance of face-to-face and virtual meetings. We also continually update our family of websites to keep the information current."

Educational activities

The MPIF has offered its Basic PM Short Course since 1965 and continues to meet the needs of the PM industry by holding several educational events each year. The Basic PM Short Course is said to be ideal for new employees, those with new assignments, or simply as a refresher course. The course will mark its 54th year in 2018; "quite a run when you consider an estimated 3,500 people have taken the course over the years," added Adams. The MPIF rotates its PM Compacting/Tooling and Sintering seminars each year, as they provide a strong base of knowledge for the attendees. Based on industry need, it usually adds one additional seminar per year, such as the recent Machinability and Post-Sintering seminars. A PIM Tutorial is also run annually, instructed by Professor Emeritus Randall German, FAPMI, and is extremely well received by the attendees.

One other area of great concern that the MPIF has helped address is the lack of metallurgists in the industry. "Twenty years ago, nearly every PM parts maker had a staff metallurgist. Over the years, as people retired or - in many cases - were victims of layoffs, the number of staff metallurgists became almost non-existent." When parts makers started to rely on external sources, such as their powder suppliers to determine problems with their parts, the MPIF, through its Technical Board, developed its 'Guide to PM Microstructures' as a reference for comparison purposes to aid in the interpretation of PM microstructures.

One of the APMI member benefits is the opportunity to take three e-learning courses (Course 101: Welcome to the World of PM; Course 102: Introduction to Compacting and Primary Press Functions; Course 103: Introduction to Sintering Fundamentals and Furnace Design) with a downloadable certificate of completion. This under-utilised opportunity could help some individuals and companies meet their annual education requirements.

Promoting metal powder technology

Whilst the MPIF's PM Showcases have certainly helped gain exposure to engineers within automotive companies, its annual Design Excellence Awards (DEA) competition is seen as a gateway to other industries. Each year, awards are presented in categories that not only champion automotive applications, but also those components found in hand tools, hardware, aerospace, military, medical and more (Fig. 9).

The federation also supports industry promotion through its Industry Development Board (IDB). The IDB has an annual budget of over $225,000 to support the marketing of the PM industry. In addition to the PM Showcases and DEA activities, it utilises electronic and print advertising, videos, social media and the PickPM.com website to promote the industry.

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The rise of Additive Manufacturing

To some, metal Additive Manufacturing might be seen as a threat to more conventional PM processes. However, Adams does not share this view and is keen to highlight the synergies and opportunity that this technology can offer. "Metal AM should not be viewed as a threat and it should be embraced by the PM community. As mentioned before, metal AM, just as stamping, casting, machining, press and sinter PM, MIM and HIP/CIP, should be selected as the process that is the best fit - one that meets all of the desired requirements of fit, form and function, and is economically sound. Typically, a customer requiring an oil impregnated bronze bearing wouldn't need to consider stampings, castings, machining, MIM, HIP/CIP or metal AM. Yes, the part could be produced by a few of these processes, but conventional PM should meet all of the requirements and be the most economical. And we have all heard of the GE LEAP engine fuel nozzle that replaced individual welded parts, increasing fuel efficiency and reducing weight. Despite increasing component cost, the improved fuel efficiency easily outweighed any additional expense. These are just two simple examples of selecting the proper manufacturing processes."

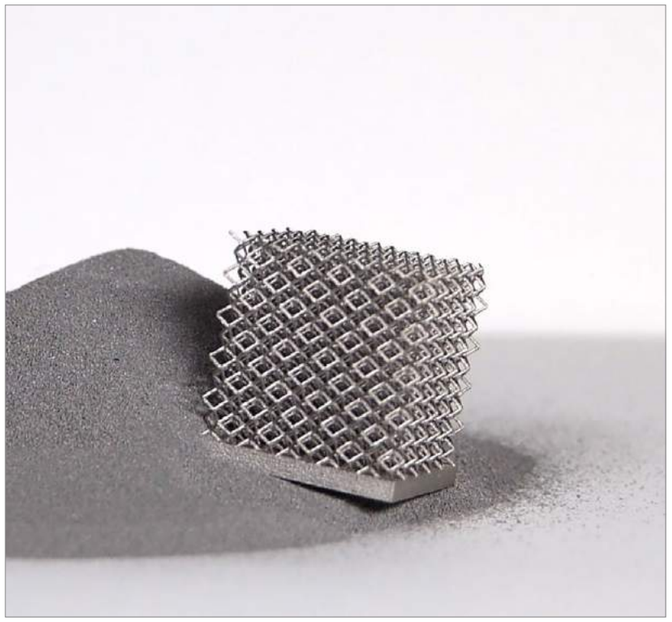

Fig. 10 The huge interest in metal Additive Manufacturing has helped improve the profile of more established metal powder based processes

Additive Manufacturing at the MPIF

Metal AM is seen as a natural fit for the MPIF, so much so that it held its first Additive Manufacturing with Powder Metallurgy (AMPM) conference to coincide with the 2014 World Congress and has held the conference every year since. "We quickly realised that many in the AM community were unaware that there was a North American PM industry as most of the equipment manufacturers were from Europe. The MPIF was able to fill this void and use its expertise to help accelerate the metal AM industry's growth."

In 2017, the MPIF's Board of Governors approved the Association for Metal Additive Manufacturing (AMAM) and all companies that join before December 31, 2018 will be considered Charter Members. AMAM currently has four sub-committees to address environmental, health & safety concerns, marketing, technical activities including standards/training/publications, and membership development. MPIF is also active with the America Makes National Additive Manufacturing Innovation Institute and American National Standards Institute (ANSI) Standardisation Roadmap for Additive Manufacturing, where Adams is a co-chairman of the Precursor Materials Committee.

AMAM will try to minimise duplication of activities that may be under development with other groups. However, AMAM will be prepared to expedite standard test methods, materials standards and best practices for safety, materials handling and equipment installations as determined by its members. There is concern that current standardisation may be excessively driven by aerospace and medical interests, resulting in requirements that are too restrictive for growth in non-critical applications. There is likely a need to have more than one set of materials properties based on the build process used, such as direct energy deposition, where the material is melted and material jetting where the material is sintered.

Feeding conventional PM processes

With the global media interest surrounding the metal AM sector, the MPIF has seen increased interest in PM and MIM. On the back of this, there was a record attendance at MIM2018 and the PIM Tutorial, as interest in spherical powders and sintering increased. Sales for the MPIF book *Atomization: The Production of Metal Powders,* by Alan Lawley, is continuing to have a rebirth.

"I have heard of cases where metal AM was investigated for new applications but ultimately MIM was selected once the customer learned more about the process," stated Adams, demonstrating how only through an understanding of all metal powder based technologies can the proper manufacturing process be selected.

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The future of the MPIF

For almost 75 years, the MPIF has served the North American Powder Metallurgy industry, actively promoting the technology and providing members with a growing list of services. The federation has changed over the years, reflecting the needs of its members and adapting to changing markets."MPIF needs to continue to evolve to meet the needs of the PM industry and the markets it serves. We will continue to work with our Asian and European counterparts to advance the PM industry globally while minimising duplication. We need to work together to continue to promote the industry's success stories and why PM is the preferred metal-working solution," Adams stated. "That being said, I am a proponent of PM use but also a realist. PM isn't always the solution and that is okay. Accepting this will hopefully prevent chasing applications that shouldn't be considered by PM, that could ultimately be detrimental to PM's future."

Commenting on the difficulty PM companies have in recruiting experienced, knowledgeable staff, Adams said, "Closer to home, my goal is to firm up the workforce with skilled employees. We have a very aggressive approach to welcoming engineering students via the NSF and CPMT Axel Madsen Conference Grants. We have assigned mentors to each student from the MPIF Technical Board." The role of MPIF mentors is to assist students pre-conference, at the conference and post-conference, helping them to make the most of the event. "We will also try to determine their thoughts about manufacturing and the PM industry in general. If we can attract 25% of the students to stay connected to the PM industry as we have historically with the CPMT/Axel Madsen recipients, we will have helped secure our future workforce. If the remaining 75% remember PM during their career and specify a new component, we will have grown the PM industry."

Welcoming new technologies

Over the years, the federation's growth has been in parallel with the growth of the industry it serves. It has witnessed many changes and openly welcomed new metal powder based technologies, keen to share its knowledge and experience for the benefit of all. Discussing the current state of MPIF membership, Adams said, "MPIF's overall growth continues. Obviously AMAM has helped with over thirty-five new members, and we continue to see new members in several associations, such as PMPA, MIMA, and PMEA." However, not all associations have shared this growth. "The powder producers and refractory members have been somewhat stagnant. This is primarily due to consolidations and disruptions within these two segments over the past five years."

It is widely accepted that the MPIF does an excellent job in promoting metal powder technology and gaining publicity through its various conferences, exhibitions and PM component awards. As with all trade associations, this is only possible with the continued loyal support of its members. "Gaining acceptance and credibility for PM technologies has been a successful accomplishment of the MPIF. The MPIF provides companies with the opportunity to openly discuss advancing the PM industry through collaboration, without fear of antitrust concerns. MPIF members are encouraged to participate in the development of standards that are acceptable to suppliers and meaningful to their customers. They are also encouraged to participate in statistics that are used to measure the health of the industry and their own companies."

"So essentially, it is in the best interest of a company to be a part of MPIF, to help drive the industry in a positive direction, through collaboration with others that have an interest in growing the industry."

"I am very proud to be a part of the organisation. I look forward to the PM industry's continued growth over the next decade and for decades to come."

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Powder Metallurgy functional materials: Applications in electric vehicle manufacture

The European Powder Metallurgy Association organised its first Functional Materials Seminar at Forschungszentrum Jülich, Germany, April 17, 2018. The event was established primarily to consider the potential impact of vehicle electrification on the future of the PM industry and to discuss the wide variety of PM functional materials that could find applications in new electric vehicles. Dr David Whittaker attended the seminar on behalf of *PM Review* and reports on presentations from experts in both industry and academia.

Currently, around 60-70% of all PM structural part production is associated with components for automotive engines and transmissions. With the trend towards alternative power systems, including hybrid and full electric vehicles, it is expected that a reduction in demand for such PM components is inevitable. In the case of engine components, these would not be required at all in fully electric drives and the internal combustion engines (ICEs) in hybrid drives would be of lower capacity, requiring smaller components. Future transmissions may also ultimately be simpler, single-speed designs, reducing demand for current PM components such as synchroniser system parts.

On the other hand, as discussed in the EPMA's Functional Materials Seminar, the changing automotive industry offers potential new opportunities for various powder-processed functional materials within the envisaged electric drives. The net balance between the level of these new opportunities and the reducing demand for some current automotive applications is clearly of significant interest to the PM sector.

This high level of interest was evidenced by the fact that demand for places at the seminar rapidly out-stripped capacity at the Jülich Centre, with registration having to be closed several weeks ahead of the event. Unsurprisingly, all of the

Fig. 1 Attendees at the EPMA's Functional Materials Seminar 2018 (Courtesy Martin Bram)

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major European PM structural parts makers and several companies from their supply chain, including powder makers, furnace manufacturers, press manufacturers and tool material suppliers, were represented among more than fifty attendees at the event (Fig. 1).

The following sections of this report have been structured around a number of broad headings, each section containing brief summaries of the presentations relevant to the particular topic. The organisers' ultimate ambition was to create a consortium and develop a collaborative project proposal, to be submitted for EU funding within the Horizon2020 programme under the umbrella of the EPMA. Initial discussions in this context were led by Peter Kjeldsteen in the final session of the seminar and are summarised in the final section of the report.

An introduction to functional materials

The day's programme opened with three introductory presentations. Firstly, Olivier Guillon gave a welcome address to delegates on behalf of Forschungszentrum Jülich's Institute of Energy and Climate Research (IEK-1), the hosts for the day, which highlighted relevant facilities and research project work.

The Institute works on developing basic materials science into industrial applications, using a scientific approach which combines materials design, synthesis, processing and characterisation. Fig. 2 presents the wide range of material processing technologies available at the Institute. A number of these processing technologies were highlighted as having applications relevant to the seminar topic. Tape casting of titanium collectors for PEM (polymer electrolyte membrane) electrolysis involves the use of powder feedstock, which is sintered to around 70% density after tape forming (Fig. 3). Associated with this topic area, the Institute is active in research on solid electrolytes.

MAX phases are a novel family of layered materials for high-temperature applications and the Institute is active in the near net shaping of these materials using a Powder Injection Moulding route (Fig. 4).

The Institute is particularly well equipped in the pressure and field assisted sintering areas of powder metallurgical processing. Equipment is available for hot pressing, hot isostatic pressing and field assisted sintering (FAST)/Spark Plasma Sintering (SPS) technology. Particular attention was drawn to a recently installed facility that can be operated in either FAST/SPS or Flash Sintering mode.

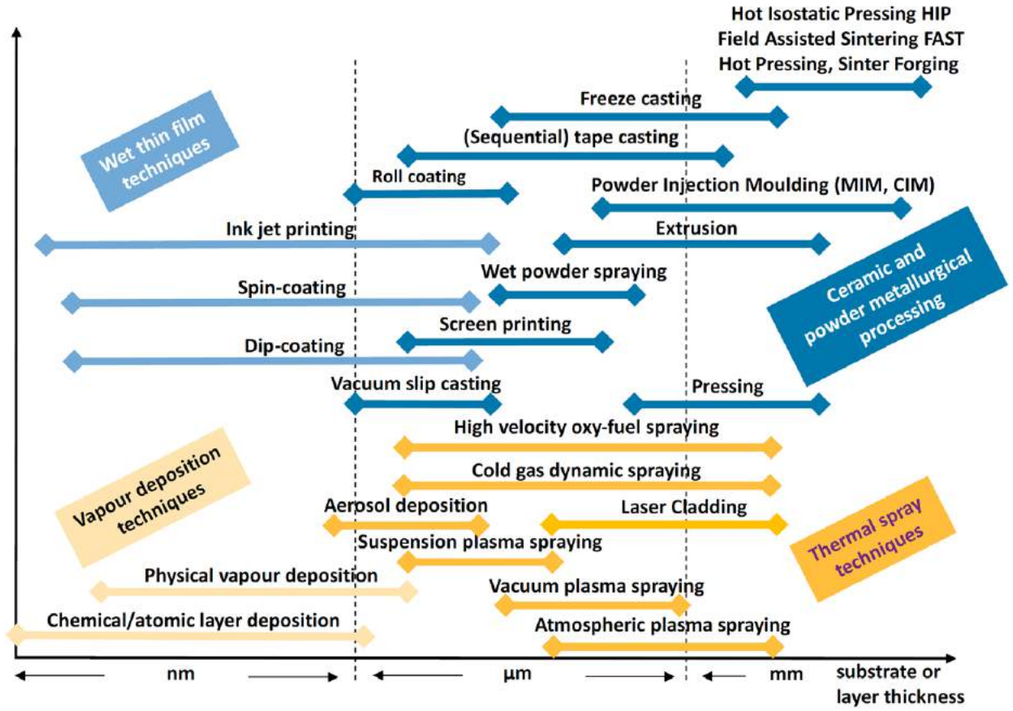

Fig. 2 Material processing technologies available at the Jülich IEK-1 Institute (From presentation: 'Powder Metallurgy @ Jülich', Olivier Guillon, Forschungszentrum Jülich)

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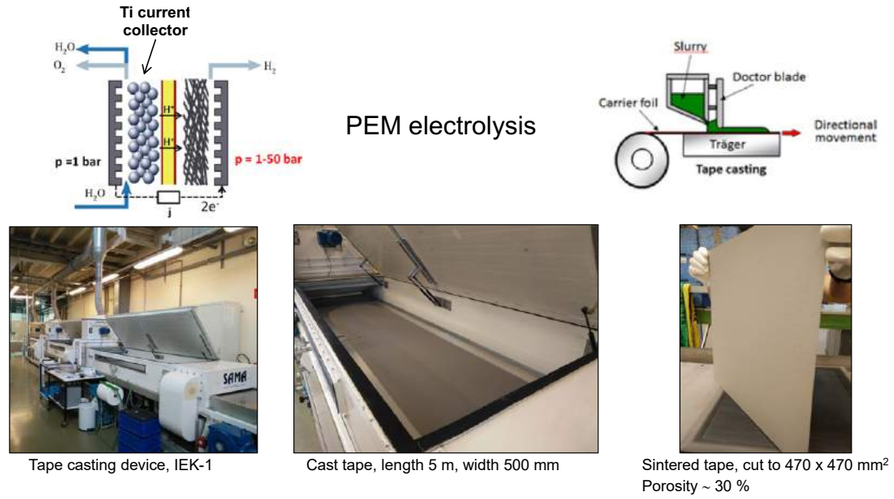

Fig. 3 Tape casting of titanium current collectors (From presentation: 'Powder Metallurgy @ Jülich', Olivier Guillon, Forschungszentrum Jülich)

A second presentation made by Lionel Aboussouan, Executive Director of the EPMA, gave an overview of the activities of the European Powder Metallurgy Association. The three key missions of the association were identified as promotion and development of PM technology in Europe, representation of the European PM Industry within Europe and internationally and the development of the future of PM.

The objectives of this seminar were placed clearly within the third of these missions. The rapidly growing activity within the EPMA Secretariat in managing EU-funded projects (four relevant projects to date were identified) and member club-funded projects (nineteen projects to date) was highlighted. It was envisaged that any project arising from this seminar would also be managed under the aegis of the EPMA.

The first session of the seminar was then concluded with a presentation by Peter Kjeldsteen, Sintex a/s, Denmark, aimed at giving a general introduction to the topic of functional materials. The general definition of functional materials was proposed as being designed materials where physical properties are manipulated or used intelligently, and where a specific geometry is not required to confer the material properties.

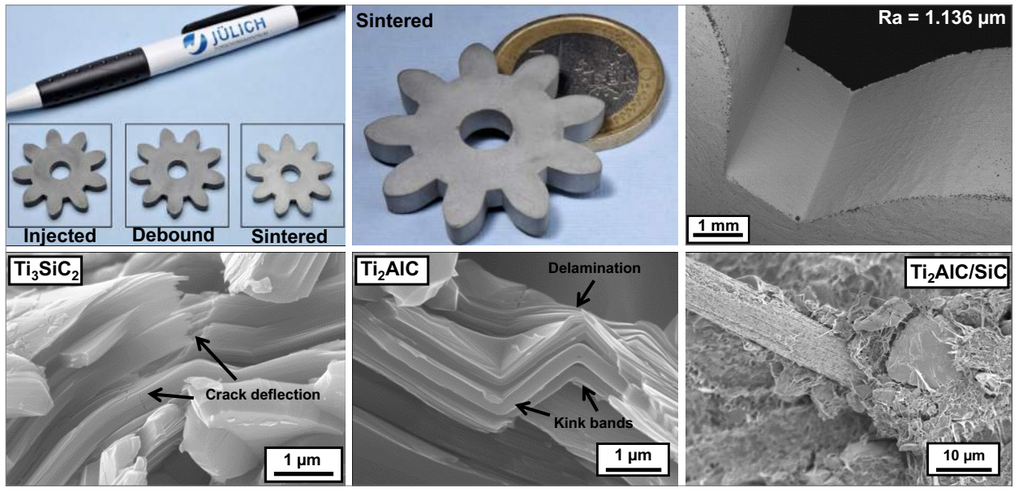

Fig. 4 Near Net Shaping of Max Phases (From presentation: 'Powder Metallurgy @ Jülich', Olivier Guillon, Forschungszentrum Jülich)

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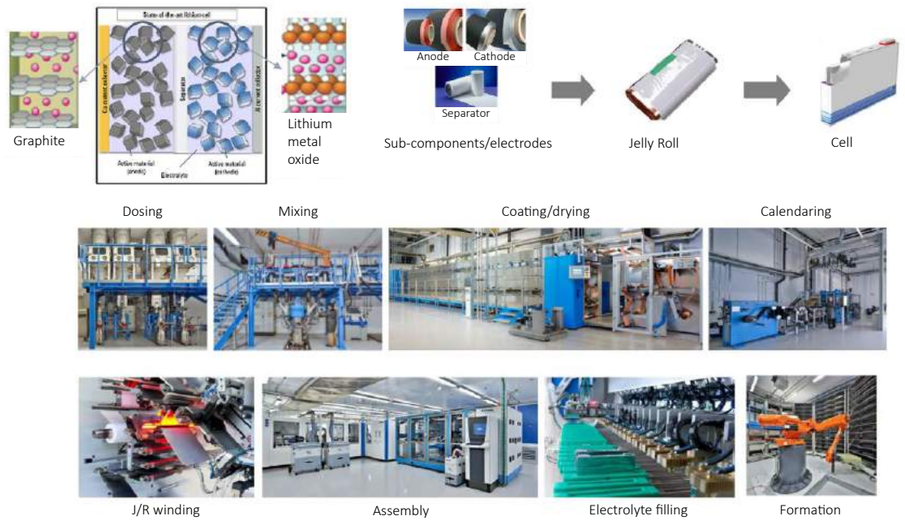

Fig. 5 Li-ion cell principle and production (From presentation: 'The battery as key component of E-mobility', Peter Lamp, BMW Group)

Examples of relevant functional properties were cited as low thermal expansion alloys (such as Invar), absorbers (such as hydrogen storage in titanium), radioactive absorbers (zirconium), filters, wick structures, magnetic properties, heat conductivity, electrical conductivity, superconductivity and catalysis.

and personal transportation systems, with solar cells, thermo-electric generation, hard and soft magnets, energy storage, fuel cell materials and AC/DC convertors cited as specific target markets.

Finally, the question was posed: "Do we have a fit with Powder Metallurgy?". The virtually universal

"BMW projects that BEVs/PHEVs will achieve a market penetration of around 20% by 2025, so suppliers of components for ICE-driven vehicles will start to see a significant impact on demand..."

Kjeldsteen stated that his confidence that there is a viable market for functional materials has been strengthened by the fact that Hitachi Group has now begun to offer 'High Functional Materials' as a separate category within its Products & Services offering. This has encouraged him to envisage potential markets for functional materials in next generation power conversion

coverage of potential material types offered by an approach that mixes constituents in powder form was identified as a positive issue. However, a number of potential challenges were also identified, such as the ability to form these materials with established PM processing routes, the ability to sinter such materials effectively and the possible hazards in handling the materials in fine particulate form.

Electrical power source materials

A group of presentations focused on battery developments, followed by two presentation focusing on fuel cells and thermo-electric generation materials respectively.

The battery as key component of E-mobility

The perspective of a leading automotive OEM on battery developments was provided by Peter Lamp of BMW Group, who described the battery as the key component in electromobility. The presentation opened with a definition of BMW's electromobility strategy. The group's ongoing strategy includes a push to regard electrification as "the new normal", and its sales of plug-in hybrid (PHEVs) and battery electric vehicles (BEVs) have already increased from virtually zero three years ago to over 100,000 in 2017. BMW projects that BEVs/PHEVs will achieve a market penetration of around 20% by 2025, so suppliers of components for ICE-driven vehicles (including PM structural part makers) will start to see a significant impact on demand for their products within a decade or so.

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From 2021 onwards, BMW aims to produce "one platform fits all powertrain derivatives" – vehicle architectures built to handle both e-drives and combustion engines. One important aspect of vehicle electrification is the availability of a viable recharging infrastructure, and the presenter stated that BMW, VW and Ford have established a collaboration to create a fast charging network.

Moving on to battery technology, it was underlined that this was the key to customer acceptance and profitability as the battery represents 77% of total e-drive system costs. Lithium-ion batteries are the preferred option and the principle of the operation of such cells and their production routes are summarised in Fig. 5. The 'state of the art' lithium cells currently contain lithium/metal oxide cathodes and graphite anodes and these electrodes are produced from powder feedstocks from a process route involving dosing/mixing and calendering.

The profitability of e-drives will depend on battery energy density improvements, and material developments are viewed as having the highest potential impact in this context. There are potential developments in both cathode and anode materials which could deliver benefits in this context, but both have technical challenges to overcome. Increasing the nickel oxide content in the mixed metal oxides additions to the cathode (to a ratio of nickel/cobalt/manganese oxides as high as 8:1:1) could increase discharge capacity from the current norm of around 160 up to around 210 $mAhg^{-1}$.

The challenges relate to decreasing thermal stability, increasing phase changes at the interface and higher reactivity with the electrolyte as nickel content is increased. The solution may

"The profitability of e-drives will depend on battery energy density improvements, and material developments are viewed as having the highest potential impact in this context..."

be to create a concentration gradient with a high mean nickel content but lower content at the surface. In relation to the anode material, the next step would be to use a silicon-based material to enhance specific capacity. The challenge here would be to find a means of compensating for the volume expansion of Si. One possible solution would be to use an anode comprising Si embedded in a carbon matrix. Combining these two electrode material developments could potentially increase energy density by 85% and reduce cell costs by 30% from current norms.

A possible further step might involve the development of an all-solid state battery, with a solid electrolyte to enable metallic lithium as the anode. This approach could potentially offer a further 45% increase in energy density. However, the challenges to this relate to the ionic conductivity and density of the solid electrolyte and interface resistances and, at present, there is no available solution that satisfies the major requirements.

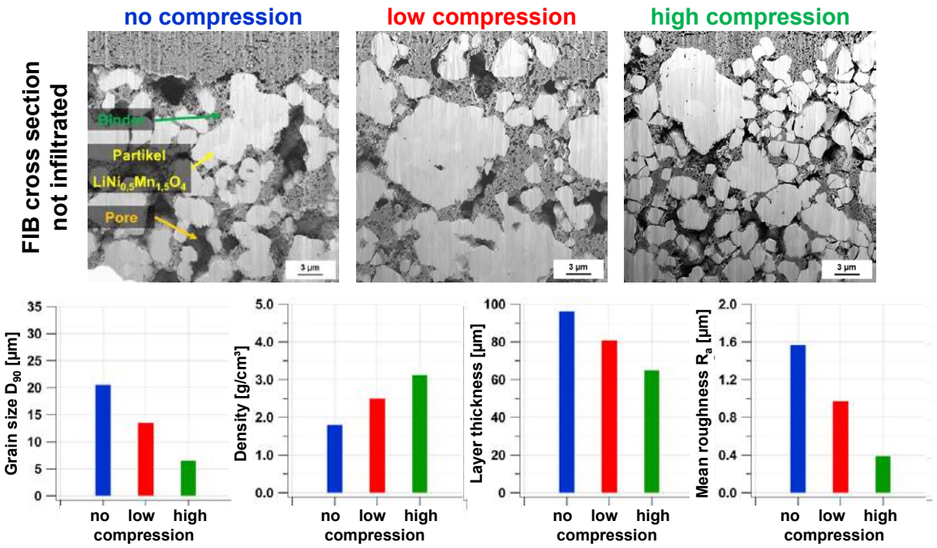

Fig. 6 Influence of calendering on the high-voltage Spinel (LiNi0.5Mn1.5O4) cathode material (From presentation: 'Powder technology for e-mobility', Timo Bernthaler, Aalen University)

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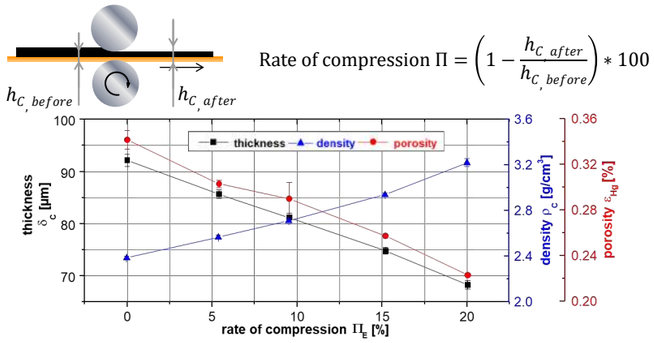

Fig. 7 Influence of rate of compression in calendering of lithium-ion battery electrodes (From presentation: 'Process induced component design for current and next generation BEV and PHEV batteries', Linus Froböse, Technische Universität Braunschweig)

Powder technology for e-mobility

A presentation from Timo Bernthaler, of the Materials Research Institute, Aalen University, discussed the Institute's studies aimed at creating a fundamental understanding of the effects of processing conditions on the microstructures created in Lithium-ion battery electrodes and in soft and hard magnetic materials.

In relation to battery processing, particular attention was paid to the compression rate in the calendering process on the microstructure of a high-voltage Spinel (LiNi0.5Mn1.5O4) cathode material (Fig. 6). The particle fragmentation at high compression (and associated influence on microstructure) is particularly apparent and similar effects were observed in studies of Lithium Nickel Manganese Cobalt (NMC) cathodes. Examples of processing effects in assembled battery cell materials were highlighted and included inhomogeneous particle size distributions, layer thickness variations, cracks in electrode coatings and the incorporation of foreign particle impurities. Overall, the presenter stated that 80% of battery performance was controlled by the electrode microstructures.

Process-induced component design for current and next generation BEV and PHEV batteries

Linus Froböse, of the Battery LabFactory, Technical University of Braunschweig, provided a presentation on how production processes influence the physical and electrochemical properties of BEV and PHEV batteries. The process steps considered for Lithium-ion batteries were mixing and dispersing, coating and drying, calendering and assembly and electrolyte filling. The analysis of battery costs presented indicated that 72% of total costs are associated with the materials and 28% are spread across all of the production steps, comprising staff costs, depreciation on equipment, capital costs, energy consumption and other costs. For mixing and dispersing, electrode resistance and capacity loss were related to carbon black porosity and energy input in the process.

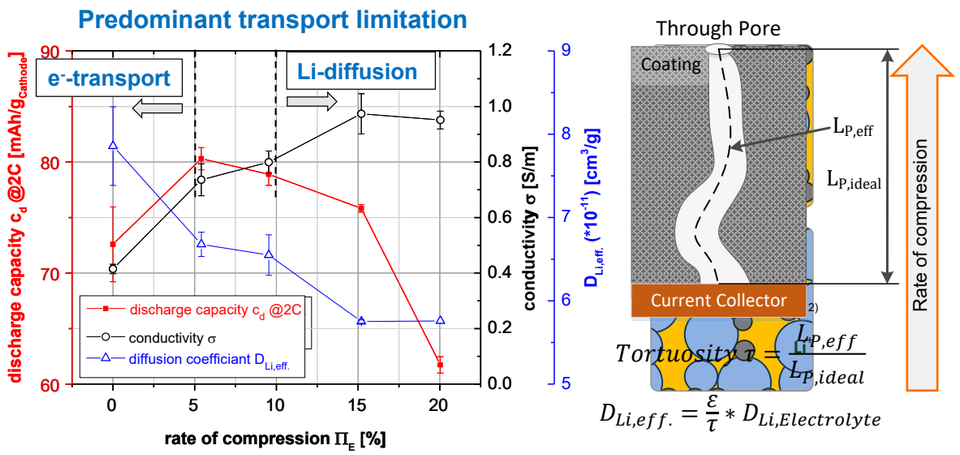

Fig. 8 – Influence of rate of compression in calendering of lithium-ion battery electrodes (From presentation: 'Process induced component design for current and next generation BEV and PHEV batteries', Linus Froböse, Technische Universität Braunschweig)

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In the calendering process, the influences of the rate of compression were assessed in relation to a number of parameters: the tortuosity of the pathways through pores, density level and conductivity (all increasing with increasing rate of compression), porosity level and diffusion coefficient (reducing with increasing rate of compression) and discharge capacity (increasing with rate of compression up to a rate of around 5% and then reducing with higher rates of compression) (Figs. 7, 8).

The powertrain of the future - the challenge of CO_2 and emission compliance

Next, a presentation from Michael Reissig, AVL List GmbH, turned attention away from batteries and to the alternative of fuel cells. AVL List has fifteen years of experience in fuel cell developments and is the owner of more than 100 patent families. This background involves both PEM and SOFC (Solid Oxide Fuel Cell) types.

If the impact on CO_2 footprint is measured on the basis of 'tank to wheel', then e-vehicles in general and those utilising fuel cells in particular have massive and virtually identical advantages over drives using internal combustion engines. However, a comparison on a 'well-to-wheel' basis shows a somewhat different picture (Fig. 9).

The influence on CO_2 footprint for hydrogen fuel cells now shows a distinct advantage over other electric drives, although it should be noted that, to make use of this advantage, issues with the 'hydrogen infrastructure' must be overcome. Of significant interest, though, is that the CO_2 reduction advantage for electric drives over current ICE-driven vehicles (Fig. 9) is greatly reduced and is highly dependent on a source of the electricity to recharge the batteries. Indeed, in China, with its heavy dependence on coal-fired power stations, electric drives may be more polluting than current petrol engines. The most reasonable CO_2 footprint comparisons would probably be the vehicle 'cradle to grave' figures shown in Fig. 10, which include the embedded carbon contents for vehicle manufacture. These figures again show the picture that electric vehicles may not be absolutely competitive by this measure, particularly in the Chinese market.

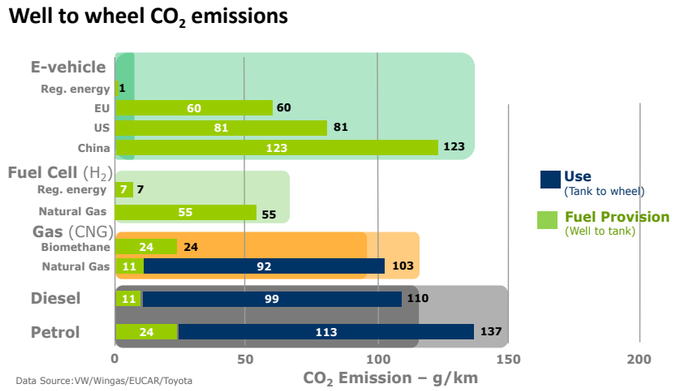

Fig. 9 'Well to wheel' lifecycle CO_2 emission comparisons (From presentation: 'The Powertrain of the Future - The Challenge of CO_2 and Emission Compliance', Michael Reissig, AVL List GmbH)

Fig. 10 Lifecycle CO_2 emission comparisons, including 'cradle to grave' data. (From presentation: 'The Powertrain of the Future - The Challenge of CO_2 and Emission Compliance', Michael Reissig, AVL List GmbH)

An AVL analysis has shown that, in terms of costs, PEM/hydrogen fuel cells show advantages over battery electric drives when the required driving range is over 360 km. In vehicle segment D (range of 500 km minimum), fuel cells will also be cost competitive with hybrids and plug-ins by 2025–28. AVL predictions for 2025 show a 50% penetration for electrified vehicles, but there will still be 100 million internal combustion engines. However, there is a high scatter and therefore a high degree of uncertainty surrounding the available predictions.

Overall, the presenter concluded that both batteries and fuel cells will be competitive. The market shares of the two options will be driven by customer choice and the development of viable charging/refill infrastructures.

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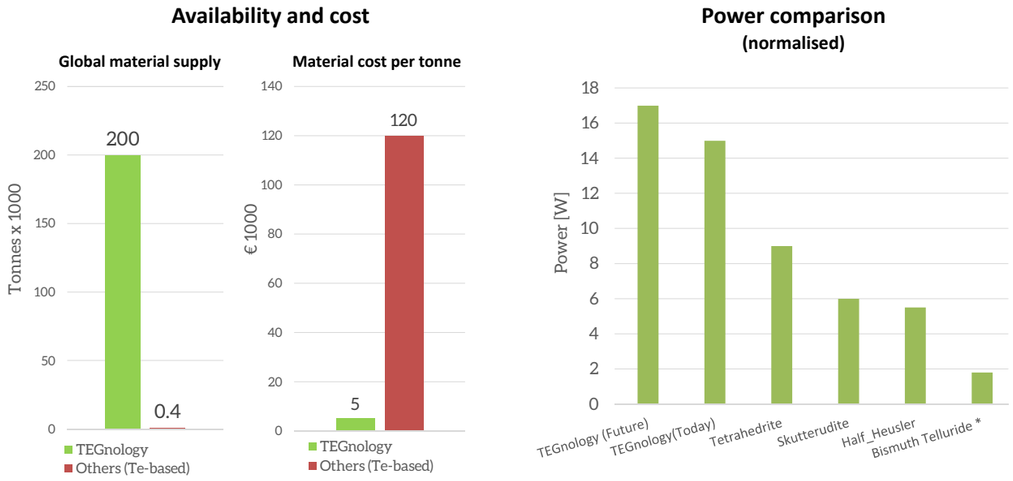

Fig. 11 TEGnology's materials advantage over the competition (From presentation: 'Key to mass-production of thermoelectric with environmental friendly materials', Hao Yin, TEGnology)

Mass-production of thermoelectric devices with environmentally friendly materials

Finally, in this topic area, a presentation on thermo-electric generation materials was given by Hao Yin of TEGnology. This highlighted a wide range of application opportunities for TEG materials, depending on the specific material's temperature capabilities: low-temperature materials for battery substitution, wireless temperature sensors for the internet of things or high-temperature, high-output materials for energy recovery. In the automotive sector, exhaust heat recovery in combustion engine driven vehicles and, in hybrid drives, provision of an independent power supply for warning systems (eg for battery overheating) were highlighted.

The presenter highlighted TEGnology's material cost and performance advantages over competing (tellurium-based) TEG materials (Fig. 11), but provided no detail on the company's current or projected future materials, other than to refer to them as being 'environmentally friendly'. He also described a manufacturing route that included SPS/FAST processing

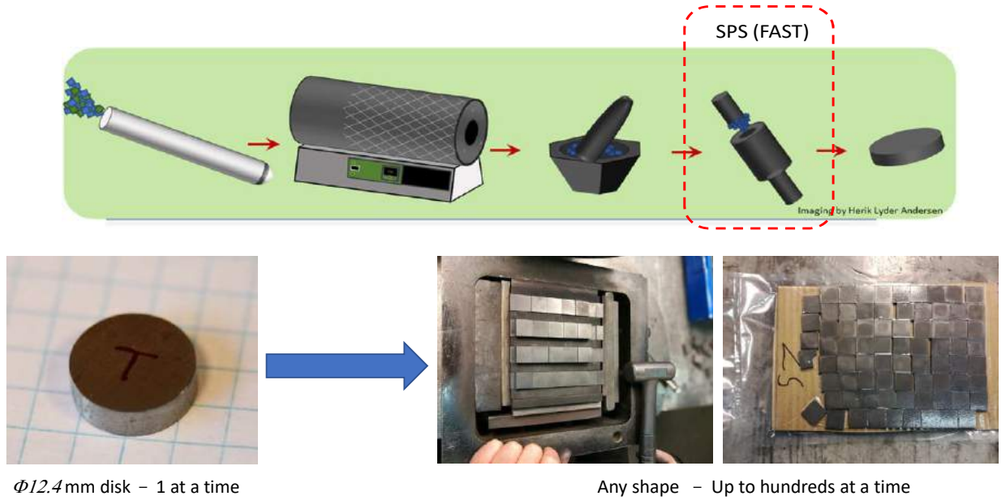

Fig. 12 TEGnology's manufacturing process route (From presentation: 'Key to mass-production of thermoelectric with environmental friendly materials', Hao Yin, TEGnology)

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(Fig. 12), which he deemed as representing the key to mass production of thermo-electric components.

Magnetic material applications

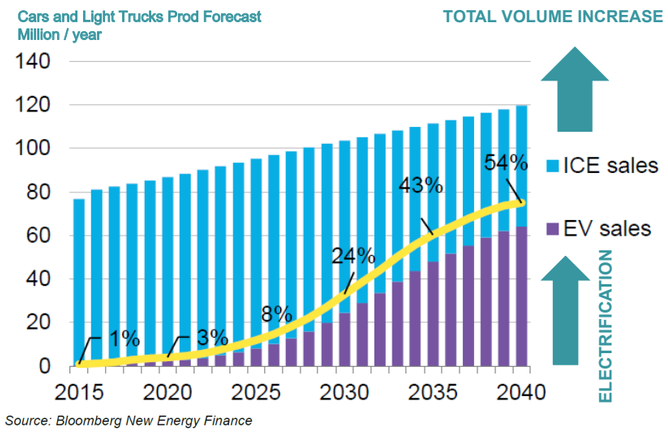
The seminar programme also included presentations featuring both soft and hard magnetic material developments.

Applications for SMC materials in future cars

Zhou Ye, Höganäs AB, highlighted applications in future cars that could usefully be served by soft magnetic composites (SMCs). This presentation began with an overview of the future car market (Fig. 13), giving the PM structural parts makers in attendance some cheer in that, although electric-drive vehicles are predicted to gain over 50% market share by 2040, this would be in the context of a total vehicle production significantly higher than current levels, meaning that internal combustion engine vehicle production would remain significant and the reduction in demand for PM applications in such vehicles would be relatively gradual.

The Höganäs Somaloy SMC family of materials were summarised as comprising ferromagnetic iron powders, an insulating coating material and a pressing lubricant addition. The PM processing for such materials consisted of mixing of powders, compaction and heat treatment, which would act to relieve forming stresses and to achieve lubricant removal.

The use of SMC components for the design for high power density using axial-flux motors (single sided and double sided) is summarised in Fig. 14. The use of this technology in electric traction drives was also discussed. Other potential SMC applications were then identified in electric air conditioner compressor drives, electric water pumps and DC/DC inverter chokes for HEV/BEV drives. The total mass per vehicle of these applications was estimated at 7–8 kg, not far behind the current



Source: Bloomberg New Energy Finance

Fig. 13 Future car market overview (From presentation: SMC materials in future cars', Zhou Ye, Höganäs AB)

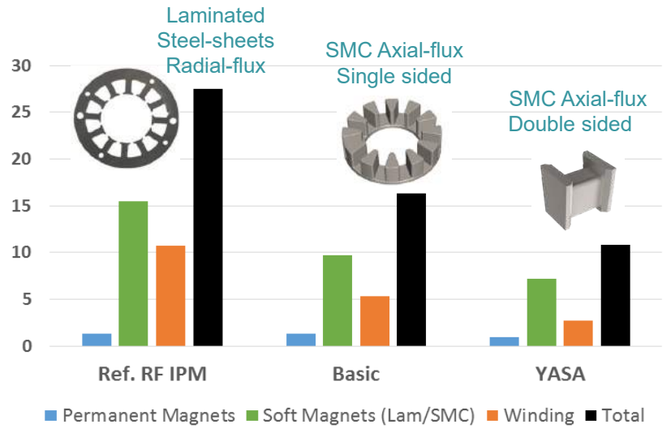


Fig. 14 Use of SMC components in designing for high power density (kW/kg) in axial-flux motors (From presentation: SMC materials in future cars', Zhou Ye, Höganäs AB)

weight of PM components found in ICE powered vehicles in Europe.

A family of SMC materials has been developed to cope with the demands of different applications. A 'base level' material can be heat treated in air at a maximum temperature of 550°C, a 'high mechanical strength' material can be steam treated at a maximum temperature of 550°C, while a 'low hysteresis loss' material can be heat treated in an inert atmosphere at a maximum temperature of 650°C (for more effective stress relief).

The operational frequency range of SMC material can be increased by reducing iron powder particle size: 250 µm diameter powder is for use in DC applications and AC applications up to 3-5 kHz, 100 µm diameter is for AC applications up to 5–10 kHz and 50 µm diameter is for AC applications up to 50–100 kHz.

Permanent magnets in future cars

Unfortunately, Bernd Grieb, of Magnequench GmbH, was unable to give his presentation on high-performance rare earth permanent

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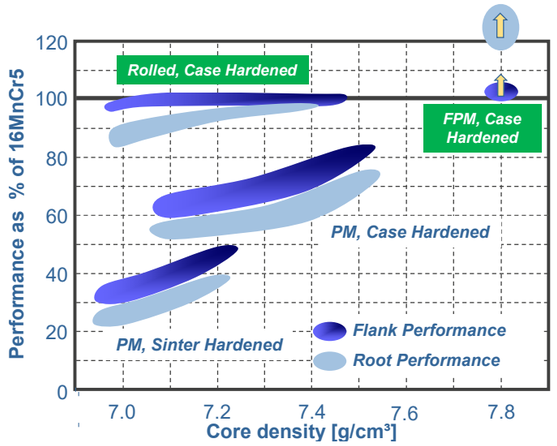

Fig. 15 Gear performance guide for rolled and for forged (FPM) PM gears. (From presentation: 'Potential of PM gears in conventional and electrified transmissions', Gert Kotthoff, GKN Sinter Metals)

magnets in future cars, because of illness. However, copies of his presentation were made available to delegates. The material developments described have arisen from work at Magnequench, DAIDO Organisation (DAIDO Steel and DAIDO Electronics) and Toyota and include:

- Advanced Quenching (AQ) Powders for increased magnetic performance in bonded magnets
- Cerium alloy materials for low cost and high-temperature capability bonded magnets. Substitution of up to 50% of the Nd with Ce (the most abundant and lowest cost rare earth) causes modest reductions of about 15% in Br and about 10% in Hci
- Grain Boundary Diffusion sintered full density magnets, with dysprosium (Dy) additions
- Heavy Rare Element Free hot deformed, full-density magnets. Magnequench's MQ3 can achieve the same magnetic properties in sintered magnets with 4–5% less Dy. It has been reported that Honda has now developed the world's first HEV motors using HREE-free magnets
- 'The Toyota Material', which is aimed at reducing the use of critical rare earth elements by up to 50%. It has been shown to be possible to retain high coercivity at high temperature through grain refinement by a factor of 10 compared with conventional magnets. Further, it has been shown that neodymium can be used more efficiently by increasing its concentration at the surface of magnet grains and reducing its concentration in the grain cores. Also, if neodymium is alloyed with a specific ratio of lanthanum (La) and cerium (Ce) (1:3), any deterioration of magnetic performance properties is suppressed.

Potential of PM gears in conventional and electrified transmissions

A presentation from Gert Kotthoff, GKN Sinter Metals, discussed the potential for the use of PM gears in conventional and electrified transmissions. GKN Sinter Metals has been a key player in a European PM sector collaboration to prove the potential of PM gear processes and technology, and has also collaborated extensively with Getrag in assessing gear performance and dimensional quality.

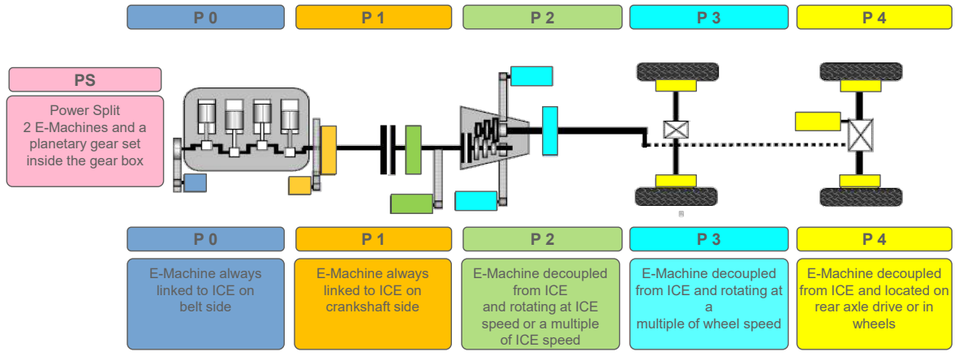

Fig. 16 The high variety of possible hybrid and BEV drive architectures (From presentation: 'Potential of PM gears in conventional and electrified transmissions', Gert Kotthoff, GKN Sinter Metals)

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The PM process routes assessed have involved surface rolling densification of press/sinter gears (for balancer gears, transmission gears and e-drive gears) and powder forging (or forged powder metal (FPM)) for differential bevel gears.

The technical viability of these PM process routes has been demonstrated. Fig. 15 compares performance with that of conventional machined and case hardened gears in 16MnCr5 steel, and shows that surface rolled and case hardened PM gears match flank performance (surface contact fatigue or pitting wear resistance) of 16MnCr5 and virtualy match root performance (tooth root bend fatigue strength) when the core density is at 7.2 g/cm^3 or higher, while powder forged and case hardened gears can exceed 16MnCr5 performance.

Turning to electrified drives, a further issue was highlighted which may increase the incentive to adopt PM transmission gears. In the absence of engine noise, NVH (noise, vibration and harshness) in the transmission becomes a significant driver comfort issue. In this context, there are potential NVH benefits, compared with machined solid steel gears, related to the use of PM gears with cores containing porosity and other integrated 'PM-tailored features'.

There are a wide variety of possible transmission architectures for hybrid and BEV drives (Fig. 16). It is envisaged that, ultimately, the trend will be towards placing the 'e-machine' in the P4 position where it would be decoupled from the ICE and put on the rear wheel axle. In such an architecture, the gearbox would be of significantly simplified design compared with the current conventional gearbox.

An initial e-drive transmission case study has involved the placing of a PM intermediate gear in such a gearbox (Fig. 17). An initial assessment of NVH performance with the PM gear (Fig. 18) has provided encouraging results and the 'motivation to do more'. An extensive test programme was therefore carried out, involving the development of 'real' off-tool and surface densified gears. A number of gear boxes were built up to firstly prove performance using a customer validation test programme, comprising NVH testing in terms of gear whine (structure-borne sound), a durability test of the powertrain, transitory torque testing and torsional fatigue and torsional strength testing.
This test series has shown that the performance requirements have been absolutely proven. In fact, the measured NVH performance was already at the lower end of the serial scatter, without having applied any active design modifications and having a PM tooth micro-geometry equivalent to that of the standard steel tooth profile. Therefore, further work is now focussing on further NVH improvement for the e-drive application, through the design of PM-tailored tooth micro-geometry and NVH-tailored gear bodies.

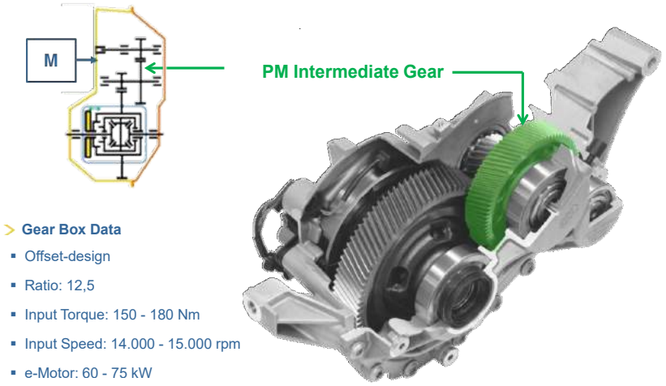

Fig. 17 The e-drive gearbox in the initial case study (From presentation: 'Potential of PM gears in conventional and electrified transmissions', Gert Kotthoff, GKN Sinter Metals)

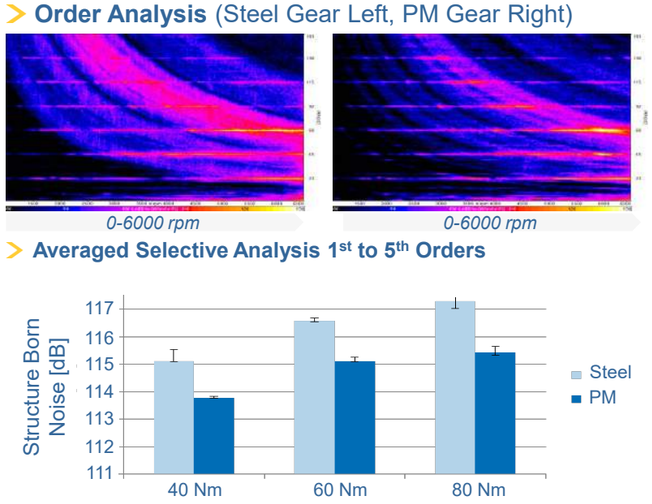

Fig. 18 Initial assessment of NVH potential (From presentation: 'Potential of PM gears in conventional and electrified transmissions', Gert Kotthoff, GKN Sinter Metals)

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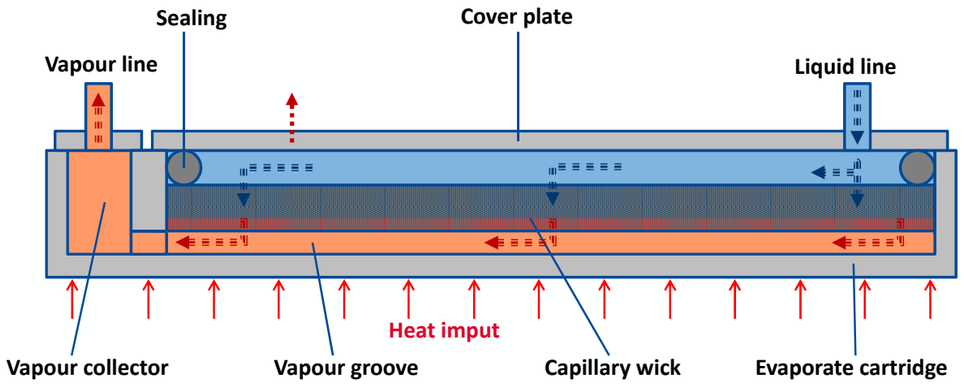

Fig. 19 Loop heat pipe technology: functional evaporator set-up (From presentation: 'Capillary wick materials in loop heat pipe application for electric vehicle', Tobias Düpmeier, Benteler Automobiltechnik GmbH)

Powder Metallurgy offers solution for a self-sustaining cooling system

A presentation by Tobias Düpmeier of Benteler Automobiltechnik GmbH focused on capillary wick materials for loop heat pipe application in electric vehicles. Loop heat pipe (LHP) technology is based on a self-sustaining cooling system, whose driving force is the pressure difference inside an evaporator, maintained by capillary forces. The system components comprise an evaporator (heat source), a condenser (heat sink), reservoir and connecting lines. Heat transport is by evaporation and condensation of a working fluid in a closed, evacuated system. A functional evaporator set-up is shown schematically in Fig. 19.

Two development examples were cited for electric drive vehicles. The first of these was in electronic cooling in BEVs. The Benteler solution for this application comprised an evaporator with a stainless steel housing and copper cooling plate and capillary structure, a plate-like condenser and a working fluid of methanol. The capillary wick was produced by loose powder sintering of copper gas atomised -25 µm powder to around 70% density with a mean pore size of 2–3 µm.

The second application was for exhaust heat recovery in hybrid vehicles for shortened cold starts and shortened ICE running times. The evaporator is placed in the exhaust line and the condenser in the coolant circuit (Fig. 20). The benefits of using LHP technology in this application are fast response times, highly efficient heat transport and the absence of an electric pump. In this case, the capillary wick plate was produced from -20 µm water atomised 316L stainless steel powder by sintering

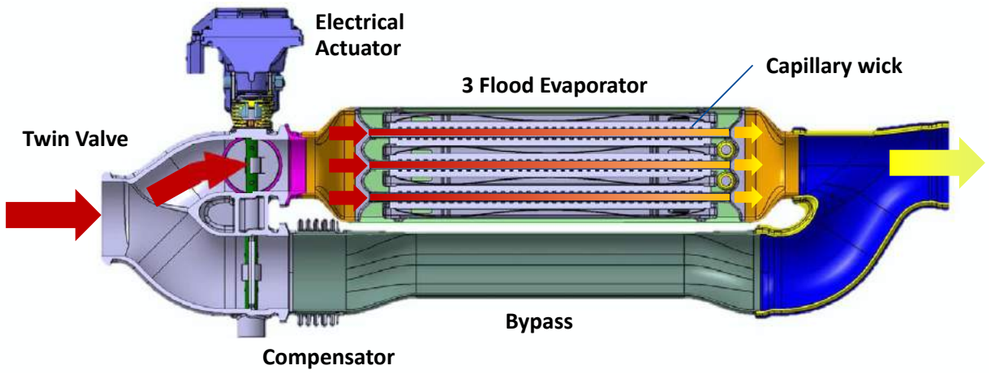

Fig. 20 LHP arrangement for exhaust heat recovery in hybrid vehicles (From presentation: 'Capillary wick materials in loop heat pipe application for electric vehicle', Tobias Düpmeier, Benteler Automobiltechnik GmbH)

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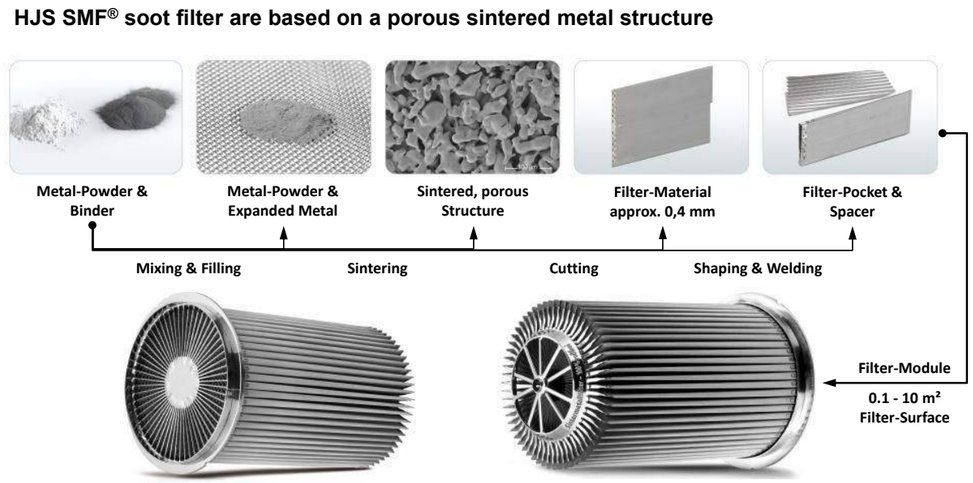

Fig. 21 Soot filters based on a porous sintered metal structure (From presentation: 'Powder Metallurgy for lower vehicle emissions', Simon Steigert, HJS Emission Technology GmbH)

a green compact at around 1200°C to achieve 50–55% density with a mean pore size of 2–5 µm. Laser welding has been used to create the connection between the capillary structure and the sheet metal housing to separate fluid and vapour.

Electrification may not be the only route to lower emissions

Finally, a presentation from Simon Steigert, of HJS Emission Technology GmbH, made the point that the electrification of vehicle drives is not the only solution to engine emission control and that, in several sectors of engine application, exhaust after-treatment will continue to be an important contributor to achieving legislative targets.

The presentation initially reviewed emission regulations across a broad range of engine markets: on-road applications (from passenger cars and motorcycles through to heavy duty vehicles and buses) and off-road applications (in construction machinery, stand-alone generator sets, marine vessels, military vehicles, railway engines and aircraft engines). The point was made that the majority of HJS's business is in the heavy duty on-road and off-road sectors and that, therefore, the company expects limited impact from vehicle electrification, because of range and charging issues.

An overall conclusion was drawn that no single emission control technology will be capable of operating alone in fulfilling the stipulated limits. Rather, depending on the application, combinations of technologies will be deployed, including diesel oxidation catalysts (DOC), NOx storage catalysts (NSC), three-way catalysts (TWC), DeNOx catalysts (SCR) and particulate filters (DPF/GPF).

HJS solutions in this range of technologies generally involve the use of sintered metal filters (Fig. 21). The point was made that design variations of the sintered metal filter are granting access to markets that do not need perfect filtration, but enhanced safety and reduced use of electronics. In relation to the required design variations, the point was made that the sintered metal technology offers the degree of freedom to create unique solutions, even in smaller volumes.

For current applications in Europe and emerging markets beyond Europe, exhaust after-treatment systems generally need several components, such as DOC, DPF and SCR in diesel engine systems and, depending on chassis design, these components can be integrated into a single unit.

In relation to ongoing development of HJS products, the demanding targets for CO_2 reduction will have a large impact on a number of design aspects, such as the needs for weight reduction, power loss reduction, electrical loss reduction (through brake power recuperation) and compensation for lower exhaust temperatures. The weight reduction issue will require improvements in the sintered metal media, in terms of thickness and efficiency.

The upcoming market for soot filters in direct injection gasoline engines for passenger cars (Fig. 22) was specifically highlighted. The future adoption of Additive Manufacturing may offer the opportunity to build soot filters with adapted designs to obtain better flow behaviour and optimised installation space. In relation to thermal management, the electrical conductivity of sintered

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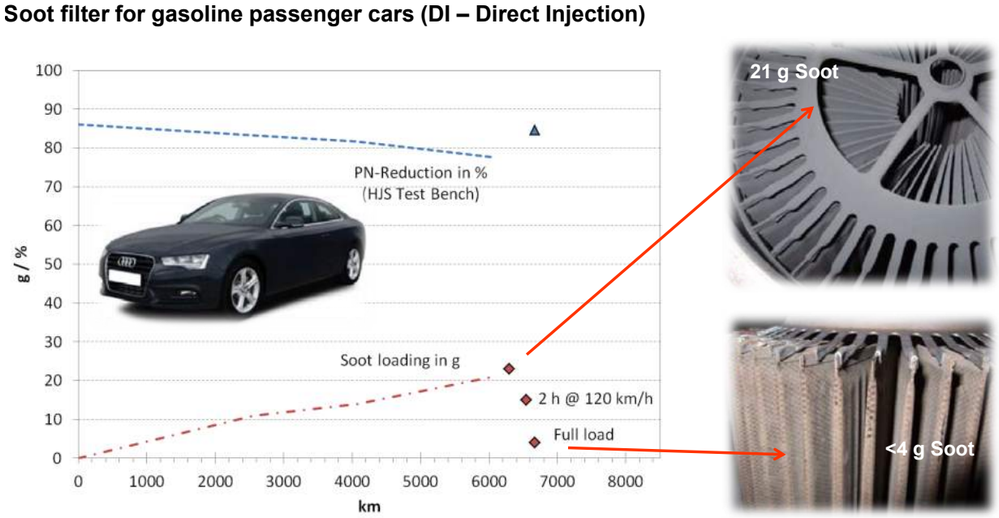

Fig. 22 Upcoming market for soot filters for direct injection engines for gasoline passenger cars (From presentation: 'Powder Metallurgy for lower vehicle emissions', Simon Steigert, HJS Emission Technology GmbH)

metal allows direct heating up of soot filters and the anticipated move from 12V to 48V power supply in passenger cars will be positive in this context.

A further upcoming market opportunity was identified in exhaust after-treatment for range extenders. In this application, very small systems, operating with quite low power, are needed.

A new Horizon2020 project

In the final session of the seminar, a discussion was led by Peter Kjeldsteen with the purpose of shaping the envisaged Horizon2020 project proposal and the associated consortium. A preliminary idea centred around the development of a concept car incorporating a selection of the component developments highlighted during the day's programme.

This idea requires further refinement and anyone with an interest in joining the consortium and contributing to this task should make contact with Rhianna Jones, EPMA Events and Projects Coordinator, at rj@epma.com.

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Organiser

The Functional Materials Seminar was organised by the European Powder Metallurgy Association. The original idea for the seminar came from Peter Kjeldsteen of Sintex a/s, Denmark, and the programme for the day was arranged with considerable input from Martin Bram at the Jülich Centre.

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Ceramitec 2018: Industry suppliers showcase the latest in metal powder processing technology

Held every three years in Munich, Germany, Ceramitec is the leading trade fair for the international ceramics industry. For many years, the trade show and accompanying conference have included a Powder Metallurgy stream, due in large part to the fact that many of the equipment suppliers exhibiting at the show provide their products not only to the ceramics industry, but also to PM manufacturers. Dr Georg Schlieper visited Ceramitec 2018 for *PM Review* and interviewed a number of exhibitors who supply equipment to sintered parts manufacturers.

Ceramitec 2018, April 10-13, 2018, was once again very well supported and attracted over 15,000 participants, of which international visitors made up around 60%. The event hosted 633 exhibitors from thirty-eight countries and in addition to the exhibition included numerous technical conferences, seminars and meetings. Included in the conference programme was a Powder Metallurgy Day, with lectures covering PM and metal Additive Manufacturing, alongside an otherwise mainly ceramics-oriented focus.

Whilst visiting the exhibition and speaking with a number of companies that manufacture equipment for both the ceramic and Powder Metallurgy markets, it became clear that innovation remains key to the industry. On show were the latest designs of powder press, including new electric and hydraulic systems. Modern tooling systems demonstrated high precision capabilities and a number of isostatic presses and furnace systems were on display.

Dorst Technologies GmbH

Dorst Technologies GmbH & Co. KG, a leading supplier of equipment for the consolidation of metal and ceramic powders, is based in Kochel am See, Germany, in the foothills of the Alps, not far from Munich. *PM Review* talked to Josef Spensberger, Deputy Managing Director for Sales, Engineering and Operations.

Dorst offers a full range of electric and mechanical-hydraulic presses for the PM industry. It's electric presses

Fig. 1 Entrance to Ceramitec 2018 (Courtesy Messe München)

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Fig. 2 Dorst's 100 ton electric press (Courtesy Dorst)

range from 6-160 tons capacity and hydraulic presses from 15-1600 tons. All presses can be equipped with multi-platen adaptor systems.

In the lower tonnage range, Spensberger identified a clear trend away from hydraulic drives towards electrically driven presses. As a technology driven company, Dorst develops presses for the highest precision combined with maximum speed. "The 800-ton press can produce green parts with a height tolerance of just 0.03 mm. This is achieved using an innovative control software that can level out powder fill variations and helps to save costs by eliminating some secondary operations," stated Spensberger.

An important topic for Dorst, as for the entire PM industry, is Industry 4.0. Dorst presses offer the option to collect large quantities of production data and report via standardised interfaces to analyse production trends. The data collection system is independent of the press control software and is not restricted to Dorst presses. The idea behind Industry 4.0 is to create intelligent, digitally networking systems that enable largely self-organised production: people, machines, plants, logistics and products communicate and intergrate directly with one another in Industry 4.0.

Triggered by the recent scandal surrounding Facebook's collection and use of user data, a key topic of discussion has been how these data should be protected. Dorst makes a strict distinction between machine data and production data. Of course, the production data belongs to the factory, but the machine data can be used by Dorst with the consent of the customer to optimise the manufacturing processes. Safe handling of these data is essential.

Spensberger expects that the average size of PM parts will become smaller in the future and that the demand for powder presses will consequently shift towards smaller sizes. "The demand for the technologically advanced Dorst presses continues to be supported by the increasing complexity of PM components." In his opinion, "electromobility will displace some sintered parts, but new PM parts will be developed in replacement." Therefore, Spensberger believes that the PM industry will cope well with the changes in the automotive industry. "However," he qualified, "predicting the future is like reading coffee grounds!"

www.dorst.de

Fig. 3 An electric press from Komage Gellner (Courtesy Komage)

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Komage Gellner Maschinenfabrik KG

The family-owned company Komage Gellner KG, Kell am See, Germany, manufactures mechanical, hydraulic and electric powder presses. The company's mechanical presses range from 5 - 50 tons, hydraulic presses from 5 - 1200 tons and electric presses from 10 - 100 tons. Komage's focus at the exhibition was on their servo-electric presses, and Hans Georg Seimetz, Consulting Sales Representative for Komage, talked to *PM Review*. Seimetz said that the servo-electric presses are equipped with up to eight independent press axes, four from the top and four from the bottom. Die and core rod movements are performed by servo-electric drives up to 100 tons capacity, with hydraulic drives for larger presses. Seimetz added that each press is custom-tailored to the needs of the customer.

Regarding the future for electric presses, Seimetz expects the main market growth in the smaller tonnage regions, and for parts with a low-to-moderate height. Where high tonnages and multi-platen toolings are required, he believes that the hydraulic presses are more flexible and better suited. "Komage is developing a new generation of hydraulic presses with less power consumption and a higher efficiency that can compete against electric presses," he stated.

Komage will install the data acquisition systems and interfaces required for Industry 4.0, and Seimetz is optimistic about the future for the PM industry. "Electrically driven vehicles will of course partly replace cars with internal combustion engines and the PM parts of these engines," stated Seimetz, "but there are many other automotive applications that will still be required, and electric driven vehicles will use new Powder Metallurgy materials and components. The PM industry is innovative enough to cope with these challenges," he concluded.

www.komage.de

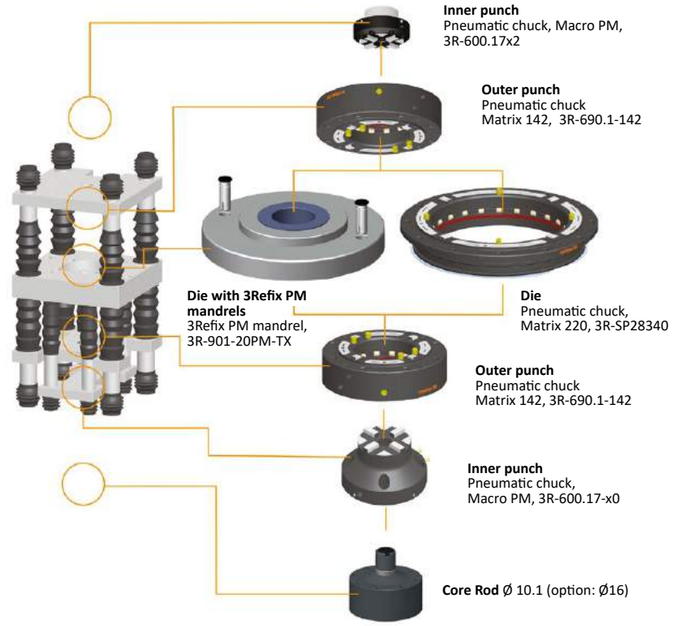

Fig. 4 Tool elements for PM tooling (Courtesy System 3R)

System 3R

Modern tooling for the compaction of high-precision powder metal parts is often a very complex system of tool and adaptor components. System 3R, a subsidiary of GF Machining Solutions based in Switzerland, has developed versatile clamping elements for toolmaking and for press tools. System 3R's high-precision clamping systems allow for faster tool changes and are said to dramatically improve the accuracy of green parts.

System 3R is manufacturer of reference systems, precision clamping systems, software and automation equipment. Reference systems are available for conventional machining operations like milling, Electrical Discharge Machining (EDM) and grinding, but System 3R claims that they are particularly advantageous when used with powder presses.

Achieving the highest possible accuracy is the ultimate goal of System 3R. "Our standard clamping systems have a repeatability of 2 µm," explained Hans Wälti, Segment Manager Powder Compaction at System 3R, "and there are even special systems that offer a repeatability within less than 1 µm." These clamping systems are designed for extremely fast tool changes; therefore, PM manufacturers who produce small quantities and have to make several tool changes every day can significantly reduce the downtime of their presses with these clamping systems. Wälti gives an example of pressing tungsten carbide indexable inserts. "When changing tools with our clamping systems, the press can continue to produce parts after just fifteen minutes, whereas, if the tool is changed without it, the press usually stands idle for half a day or more."

"In order to take full advantage of our reference systems," said Wälti, "it makes sense to use them in the production of the stamps, during milling, on the grinding machine, during EDM machining, etc. This way the user can preserve the high accuracy throughout the entire manufacturing process." According to Wälti's

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assessment, the further development of press technology demands ever-higher accuracies associated with increasing productivity.

www.system3r.ch

Osterwalder AG

Osterwalder AG, based in Lyss, Switzerland, is a privately held company focused on the manufacture of powder presses for metal, carbide and ceramic applications. Jens Moecke, Director Marketing and Product Management, told *PM Review* that he sees the future of powder presses in fully electric equipment. "With a force of 200 tons, Osterwalder offers today the most powerful electric powder press and it is planned to extend the family of electric powder presses to a maximum capacity of 500 tons."

Moecke listed the many advantages of electric powder presses over mechano-hydraulic presses. "The reduced energy consumption is the main economic factor," he said. "Our 200 ton electric press consumes 9-10 kW, a hydraulic press of the same size needs 60-70 kW energy. There is also a certain increase in accuracy due to the electric drives that can be controlled more precisely than hydraulic drives. An important factor is maintenance; users of hydraulic presses know the problems with leakage at sealing elements. High power hydraulics need cooling water and, after a standstill, it takes time before a hydraulic press has been warmed up for the next production run. In addition, the electric press does not need a press pit, generates much less noise and is more durable than a hydraulic press."

Osterwalder has calculated annual cost savings to be around €200,000 for the 200 ton electric press in comparison with a hydraulic press of the same size. These cost savings, along with the other benefits of electric presses, were stated as motivation for Osterwalder to concentrate its activities on electric presses in the future, moving away from the hydraulic press system.

www.osterwalder.com

Sacmi Group

One branch of the Sacmi Group, headquartered in Imola, Italy, focuses on machinery for the ceramics industry. However, presses for Powder Metallurgy were seen as a natural supplement for this sector. Frank Kudies, Special Pressing Representative of Sacmi, told *PM Review* that the company entered the PM press market around ten years ago through its acquisition of the Italian press manufacturer Matrix.

"Today, Sacmi manufactures high-quality mechano-hydraulic powder presses with a press force of between 33 and 800 tons," stated Kudies. "All presses are CNC controlled and offer multi-platen technology." In cooperation with other companies of the Sacmi Group, the branch is able to offer suitable automation systems for its presses.

"We see that the electric press offers advantages for certain applications," Kudies added, "but the hydraulic presses will continue to be very important in powder pressing. Our goal is to further improve the performance of hydraulic presses to offset their disadvantages; such as increased space and energy requirements through higher productivity."

www.sacmi.it

Fig. 5 Osterwalder's 200 ton electric press (Courtesy Osterwalder)

Fig. 6 Sacmi exhibited a 200 ton hydraulic press at Ceramitec (Courtesy Sacmi)

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Fig. 7 Gasbarre manufactures a wide range of sintering furnaces and powder compaction and sizing presses (Courtesy Gasbarre Products Inc)

Gasbarre Products Inc.

Gasbarre Products Inc. is a group of companies that supplies powder presses, tooling and sintering furnaces specifically to the powder metal and ceramics industry worldwide. With forty-five years of experience in PM technology, Gasbarre presents itself as a supplier of a comprehensive list of production equipment and services. The group's US headquarters are located in DuBois, Pennsylvania, within an area having a high concentration of PM companies, allowing it to have frequent exchanges with engineers from the manufacturing practice.

Gasbarre Press Group manufactures mechanical compacting and sizing presses, hydraulic, electric and dry bag isostatic presses and claims to offer the widest selection of presses and accessory products available on the market. Advanced CNC control and multi-level tool design are standard. A special focus is on high-speed mechanical compacting and sizing presses. Hydraulic powder presses range from 15 - 1600 tons capacity.

The Gasbarre Furnace Group is just as versatile as the Press Group. Products range from continuous mesh belt and pusher furnaces with controlled atmospheres to batch type and continuous vacuum furnaces. The continuous vacuum furnace works similarly to a pusher-type furnace. The parts are placed on trays which enter a first chamber at the entrance for evacuation and preheating. Then the door to the sintering zone is opened and the parts are transferred to the hot zone. When sintering is finished, another door opens to the cooling zone and there the parts are gas cooled or liquid quenched depending on the requirements.

Mark C Thomason, International Sales Manager of Gasbarre Products, has an optimistic attitude towards the future of the PM industry. In his opinion, the PM industry serves so many different markets that even a slump in a certain sector will not threaten the industry as a whole. Even the expected changes in the automotive industry due to electric drive systems will only shift the demand to other PM products, but will not significantly weaken the PM industry. "The engines of cars may change from fossil fuels to hydrogen or electric power, but they will still need PM components for suspension, seats and many other applications," he said.

As an example of a growing market outside the automotive industry, Thomason mentioned lawn and garden equipment which is quite substantial in the US, much more than in the rest of the world. He predicted that the demand for outdoor equipment will increase over the coming years.

www.gasbarre.com

Cremer Thermoprozessanlagen GmbH

Cremer Thermoprozessanlagen GmbH, a family enterprise based in Düren, Germany, is known for its manufacturing of continuous and batch sintering and heat treatment furnaces. Cremer's flagship is the walking-beam furnace, a continuous furnace for high temperature sintering up to 1600°C in hydrogen/nitrogen atmospheres. In combination with a separate zone for thermal, solvent or catalytic debinding in front, it is marketed under the trade name 'MIM-Master'.

A few years ago, Cremer opened a new business area by developing hot and cold isostatic presses. Marc Knauff, Head of the company's HIP / CIP Team, talked to *PM Review* about the intentions behind this new activity and the present status of

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Fig. 8 Ingo Cremer (right) demonstrating the HIP prototype to the author (Courtesy Georg Schlieper) and a CAD model of the press (Courtesy Cremer)

the project. "Cremer's extraordinary success with the MIM-Master in the MIM industry worldwide raised thoughts about how else it could serve this growing industry," he stated.

Ingo Cremer, the Managing Director, found that for many applications it is beneficial to remove the residual porosity which is still present in most MIM products after sintering by a subsequent HIP treatment. HIP treatments are often required in aerospace and medical applications.

"The aerospace industry places the highest demands on the fatigue and impact resistance of aircraft components and pores creating an internal notch effect are absolutely forbidden," added Knauff. "In medicine, mechanically loaded components, such as hip joints, must also be fatigue resistant. Surgical instruments must also be pore-free for hygienic reasons, as bacteria can settle in the pores. The polishing results of MIM parts are also significantly improved by a preceding HIP treatment. As the residual pores in MIM parts have no connection to the surface, parts can be HIPed without a separate containment."

In a series of scientific investigations, Cremer determined the temperatures and pressures required for the elimination of residual porosity in MIM materials. His objective was to design a HIP system specifically tailored to the requirements of the MIM industry, with the right capacity and just enough pressure and temperature to consolidate the MIM products of the user.

www.cremer-ofenbau.de

Fig. 9 EPSI offers a range of Cold and Hot Isostatic Presses (Courtesy EPSI)

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Engineered Pressure Systems International N.V.

EPSI, based in Temse, Belgium, is a specialist in the production of high-pressure cold, warm and hot isostatic presses. Maxime Pauwels, Area Sales Manager of EPSI, talked to *PM Review*.

Applications of Cold Isostatic Pressing (CIP) technology are found in the processing of ceramic, carbide and refractory metal powders as well as for stainless steel filters (Fig. 9). "CIP systems with pressure vessels up to 2000 mm diameter and more for pressures up to 1000 MPa have been manufactured by EPSI, with the pressure medium usually being oil or water. Isostatic pressing in an autoclave with completely or partially rubber-elastic moulds has an advantage over pressing in dies in that the pressure acts uniformly on all sides. Therefore, the powder is uniformly compressed and the product takes on a very uniform density. In addition, very large components can be produced since the size of the compacts is limited only by the size of the pressure vessel," stated Pauwels.

Hot Isostatic Pressing (HIP) is mainly used for semifinished products of high-speed tool steel and nickel base superalloys. "Gas atomised powder is filled in cans that are evacuated and hermetically sealed before they are placed in the autoclave of the press. The pressure medium for HIP is usually argon gas." EPSI offers HIP systems from laboratory size up to 1650 mm inside diameter with maximum pressures of 400 MPa and temperatures of 2000°C.

www.epsi-highpressure.com

FCT Anlagenbau GmbH

A wide variety of furnaces for sintering ceramic and powder metal parts in vacuum or gas pressure are also offered by FCT Anlagenbau GmbH in Sonneberg, Germany. Among other products, FCT manufactures equipment for spark plasma sintering, an innovative process which enables the production of composite materials with unique properties. Spark plasma sintering is performed in a closed die under pressure and the heat is generated by a direct or pulsed electric current running through the punches as well as through the die and/or the product.

Fig. 10 MIM furnace developed by FCT Anlagenbau (Courtesy FCT Anlagenbau)

The main business of FCT, however, is vacuum furnaces with hot zones of graphite or refractory metal and MIM furnaces with controlled atmospheres or vacuum. Horst Böttcher, Sales Manager of FCT Anlagenbau, told *PM Review* that FCT has strong activities in the MIM sector and that he expects further growth of the MIM industry in upcoming years. The range of heat treatment systems for MIM offered by FCT extends from thermal debinding ovens or solvent debinding systems to sintering in controlled atmospheres or a high vacuum.

Böttcher specifically referred to a vacuum/gas pressure sintering furnace for producing high volume MIM parts (Fig. 10). This furnace combines thermal removal of the backbone binder from brown parts that have previously been subjected to a solvent debinding step followed by sintering in vacuum, subsequent gas pressure sintering for full densification and finally accelerated cooling in vacuum, hydrogen, nitrogen or argon under high pressure. Organic binder constituents are completely removed and degraded by thermal post-combustion. The maximum temperature is 1500°C with a maximum pressure of 100 bar. The parts are finished after sintering without any secondary operation.

www.fct-anlagenbau.com

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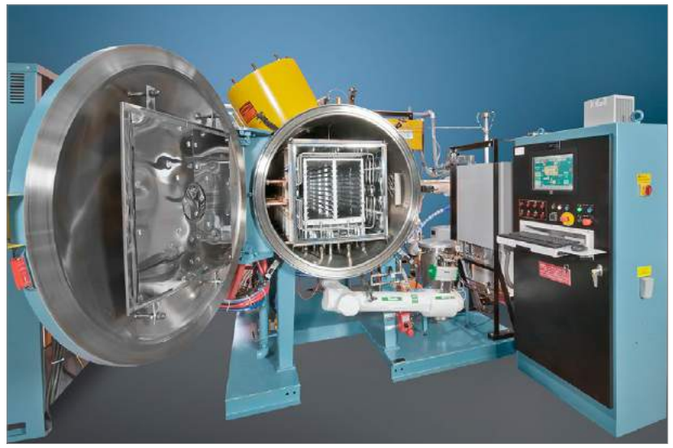

Fig. 11 Centorr vacuum furnace for MIM parts (Courtesy Centorr Vacuum Industries)

Centorr Vacuum Industries

Centorr Vacuum Industries, headquartered in Nashua, New Hampshire, USA, is one of the oldest vacuum furnace manufacturers in the United States and has been exhibiting at Ceramitec for more than thirty years. The company specialises in laboratory and production-size high-temperature furnaces for vacuum and controlled atmosphere heat treatment, hot pressing, sintering and a variety of other processes.

Scott K Robinson, Market Manager for Centorr Vacuum Industries, told *PM Review* that the company's furnaces are used by the PM industry primarily for sintering materials that require a delicate heat treatment process, such as stainless steels, superalloys, high-speed steel, titanium and others. Centorr also offers dewaxing and sintering furnaces for the MIM and hardmetal industries. Metal Injection Moulding is a main focus of Centorr's business.

Centorr has invested a lot of time in optimising the temperature uniformity during the sintering process in a partial vacuum that is mainly used in the MIM industry. The protective gas, typically hydrogen or argon, is introduced into the furnace charge by means of a box with thousands of holes through which the gas spreads out uniformly with a minimum of turbulence and flows over every tray of the furnace charge.

With this technique, Centorr is able to achieve temperature variations within less than 5°C, even for very large furnace loads. Robinson compared the gas inlet into a furnace with a shower head, "gas tends to flow like a liquid in the 300 mbar pressure range," he said, "and a large number of holes yields a much more uniform flow than a single or just a few gas openings."

The metal alloy of the sintered parts determines whether a furnace with graphite heating or one with a heating zone made of refractory metal is used. Low-alloy steels, tool steels and hardmetals with a defined carbon content are best sintered in a graphite furnace in vacuum or a partial gas pressure containing little or no hydrogen, whereas stainless steels and titanium must be free from carbon and require sintering in a refractory metal furnace in high vacuum or partial pressures of hydrogen and/or argon. Hydrogen atmospheres in graphite furnaces tend to gradually degrade the graphite heating elements and insulation by producing methane gas when fired at MIM sintering temperatures.

www.vacuum-furnaces.com

A positive outlook for Powder Metallurgy

The discussions had at Ceramitec 2018, though not a representation of the entire PM industry, seem to reflect a positive view of the current economic situation of the European and North American PM industry.

Innovative products from equipment suppliers, such as the electric press, are readily accepted by the industry and enough financial resources appear to be available for investments in this modern machinery. Despite the growth in popularity of electric presses, however, it was clear that hydraulic presses do still have a future, especially in the upper pressure range.

Powder Metallurgy has firmly established itself in recent decades as a reliable volume manufacturing process, conserving energy and reducing raw material usage. It can be seen that the PM industry has entered the digital era and, step by step, is preparing itself for Industry 4.0.

Suppliers of sintering furnaces and isostatic presses are benefitting from the continued growth of the MIM sector, and the rise of metal Additive Manufacturing will no doubt continue this trend. Although there are challenges ahead, not least with the expected move to electrified vehicles and a reduction in traditional PM parts, many are optimistic that sufficient new applications will arise to offset any losses.

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Sumitomo Electric: Optimising green machining for integration into a high volume production line

As the design complexity of automotive components increases, many parts makers are seeking to optimise processing steps to maintain the high levels of productivity that make Powder Metallurgy a viable option. One option is the green machining of PM components and this was the focus of a report published by Japan's Sumitomo Electric Sintered Alloy, Ltd. Here, the challenge was to successfully establish high volume production of variable valve timing components requiring complex green machining operations.

Sumitomo Electric Industries Co Ltd. (SEI) is the second largest manufacturer of Powder Metallurgy parts in the world, with global production of over 80,000 t/year. The Japanese company produces a wide range of PM products, mostly for automotive and HVAC (Heating, Ventilation and Air Conditioning) applications, at facilities in Asia, North and South America, and Europe.

Through its commitment to R&D, SEI has published numerous papers and has patents relating to many technical advancements in sintering processes and production equipment. One such area of research has lead to the development of green machining technology as a more cost-effective route for the production of high-quality VVT parts. Naoto Igarashi and colleagues at SEI reported on the new green machining approach in *SEI Technical Review*, No. 85, October 2017.

Variable valve timing systems

In recent years, variable valve timing (VVT) systems produced by pressing and sintering have increasingly been used for automotive engines to boost fuel economy and reduce exhaust emissions. The most common VVT systems currently in production are hydraulic, as they require fewer parts and are therefore cheaper to produce. A hydraulic VVT system is mainly comprised of a sprocket, housing and rotor, the shapes of which lend themselves to production by the Powder Metallurgy process.

Rotor (intake) Rotor (exhaust)

Fig.1 External appearance of sintered VVT rotors produced by Sumitomo Electric Industries Ltd (Courtesy SEI)

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However, rising concerns about the environment and demands for improved fuel efficiency have led to the functions and performance of VVT systems being further improved. For example, the oil passages formed in the systems for hydraulically controlling the component parts are becoming more complex, as can be seen in Fig. 1 which shows a VVT system with a built-in oil control valve (OCV).

The OCV, which is formed by additionally cutting oil grooves in the inner diameter surface of the VVT rotor, controls the flow of pressurised oil to minimise the number of parts necessary. Since it is usually impossible to form horizontal holes or inner diameter grooves with tooling in a conventional powder compaction process, these holes and grooves are normally machined after the parts are sintered. Deburring after machining further increases the manufacturing cost and in some cases may also deteriorate the quality of the VVT parts.

Incorporating green machining technology

In addition to successfully manufacturing high numbers of VVT rotors, engineers at SEI were tasked with establishing a method for accurately drilling a number of complexly-arranged holes and inner diameter grooves for a built-in oil control valve. The establishment of a touchless, stockless process, that allowed for the traceability of each part, was also seen as an essential requirement for the overall success of the project.

Igarashi and his team therefore looked at incorporating a green machining step in the production line. Green machining is the process of machining a PM component in which the powder particles are not yet metallurgically bonded together (Fig. 2). Unlike the usual process route for producing PM parts by pressing and sintering followed by required machining, the green machining route integrates machining of the green compacts immediately after the powder compaction stage (Fig. 3).

Compared with conventional sintered part machining, green machining can be used to process parts at lower shearing stress. There are also a number of other advantages to machining PM compacts in the green state. The process results in a reduction of cutting tool wear and allows the use of relatively

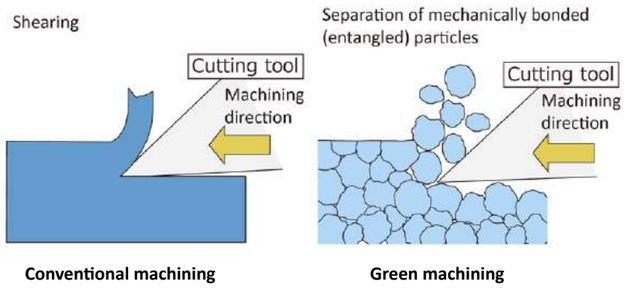
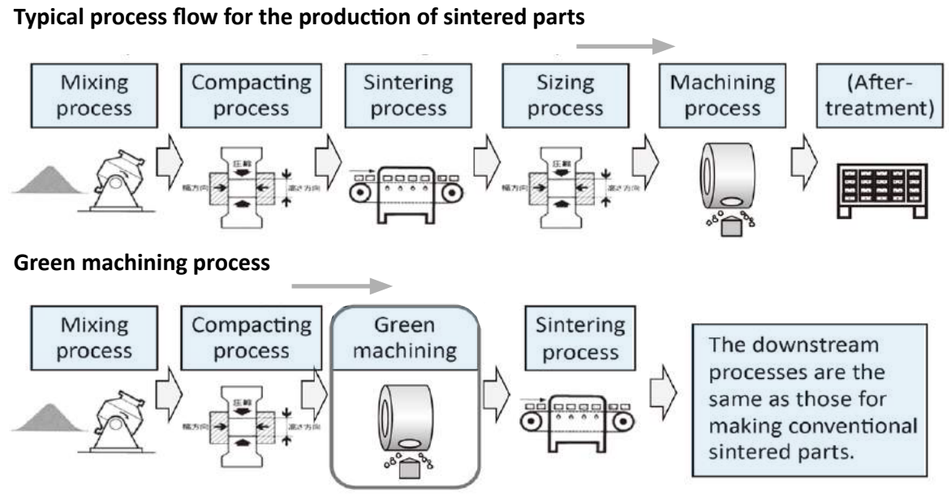


Fig. 2 Comparison between conventional and green machining (Courtesy SEI)



Green machining can be used for processing a part or the whole of the green compact

Fig. 3 Conventional part sintering process flow and green machining process flow (Courtesy SEI)

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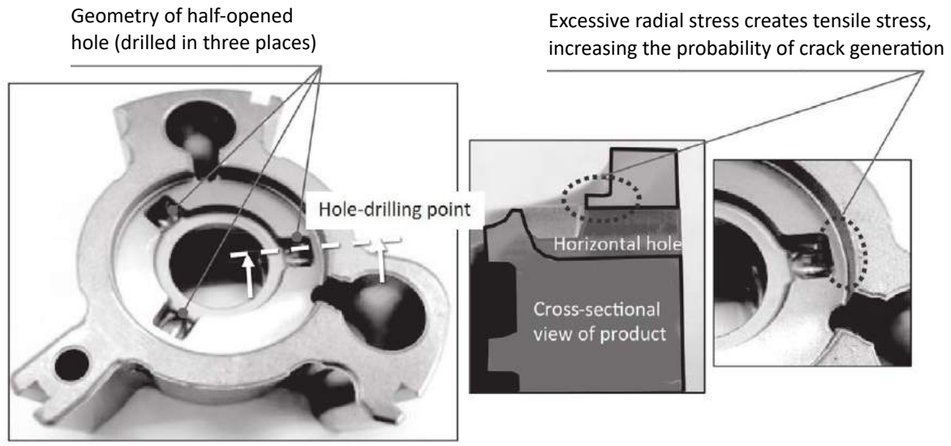

Fig. 4 Geometry of horizontal holes drilled by green machining and cross section view of VVT component (Courtesy SEI)

compact processing equipment due to the low cutting resistance. The method also prevents the production of burrs, since it does not plastically deform metal particles.

However, the process is not without problems. Green machining can result in numerous issues, including:

- the workpiece may chip or suffer cracks
- the parts of the workpiece that can be machined are limited due to low dimensional accuracy and large surface roughness (such parts must be machined after sintering the workpiece);
- dust-prevention measures and special-purpose workpiece handling systems are required.

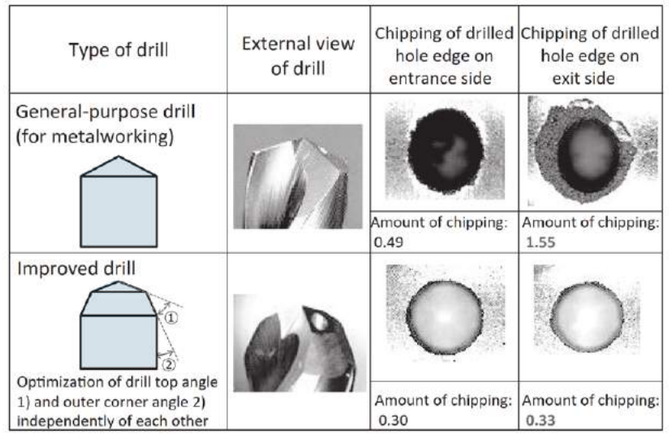

Fig. 5 Design and performance of special purpose drill used for green machining horizontal holes in VVT rotors (Courtesy SEI)

Preventing chipping and cracking in green compacts

The VVT component design incorporates horizontal holes that must be drilled through thin walls (Fig. 4). Drilling these holes was expected to create excessively large radial stress, causing the stressed parts to crack. Although it is possible to limit the risk of chipping and cracking by increasing the density of the compact or adding a binder to the powder, this can lead to additional problems such as shorter tool life and increased material costs. The authors, therefore, looked at the cutting tool itself and investigated options to reduce the chipping and cracking of green compacts through the design of a new drill.

When drilling a hole in a green compact it was found that reducing the outer corner angle of the drill decreased the cutting resistance, thereby minimising chipping at the edge of drilled holes on the entrance side. A tool with a reduced top angle was also found to optimise the stress distribution in the thrust and radial directions, and thereby reduce chipping at the edge of drilled holes on the exit side, eliminating crack generation in thin walls. As shown in Fig. 5, the newly-developed tool reduces the size of chips at the edge of the drilled hole on the entry side from 0.49 mm to 0.30 mm, and on the exit side from 1.55 mm to 0.33 mm.

Green machining of inner diameter grooves

The VVT system with a built-in oil control valve also requires a passage to be constructed by running a horizontal hole through an inner diameter groove, as shown in Fig. 6. Deburring of the horizontal hole

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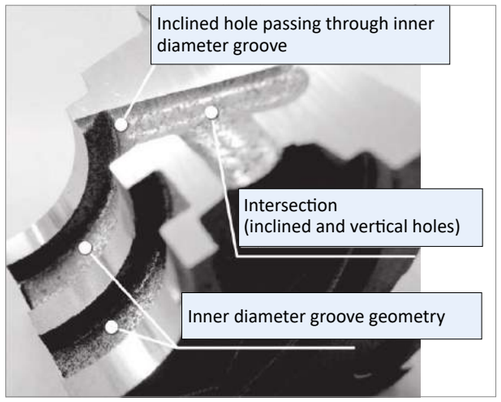

Fig. 6 Example of product processed by green machining (Courtesy SEI)

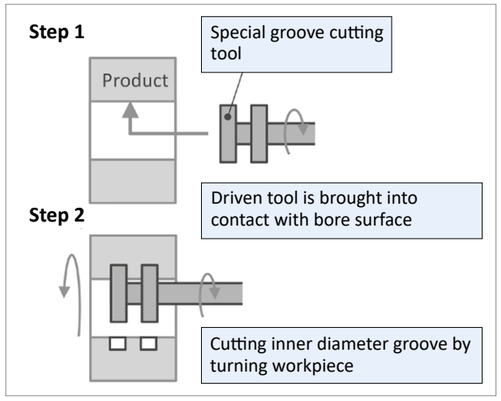

Fig. 7 The inner diameter groove cutting method (Courtesy SEI)

is said to be difficult if the inner diameter groove is machined after sintering. To eliminate the need for deburring, the team at SEI applied green machining to both the horizontal hole and inner diameter groove.

Inner diameter grooves are typically cut on a lathe; however, using a lathe, when a green compact is prone to cracking due to the force required to hold the compact in chuck. To overcome this issue, it was decided to cut the inner diameter groove on a machining centre. A purpose designed cutting tool, having the same geometry as the groove, was developed at SEI. The helix and clearance angles of the new tool have been optimised to suppress the generation of stress in the workpieces, thereby protecting them from chipping. The newly developed cutting tool, demonstrated schematically in Fig. 7, is said to enable one-chuck machining of many complexly arranged holes and inner diameter grooves.

Ensuring product traceability

The ability to trace components and provide a manufacturing history of the production process can prove indispensable when seeking to minimize the risk of product quality deterioration. Such codes help correctly detect any changing points in manufacture and identify the specific equipment used in its production.

For the VVT system, it was reported that a two-dimensional code was chosen as a way of representing this information. Compared with a 1D code (bar code) that represents information in only the transverse direction, the 2D code represents information in both transverse (horizontal) and longitudinal (vertical) directions, thereby making it possible to encode more bits of information and minimise the print area. A laser marker can print a 2D code on each green machined part prior to sintering.

Production System	Advantage	Disadvantage
Intermittent	• Minimises the number of pieces of green machining equipment (small equipment investment)	• Increases the risk of product quality deterioration (frequent contact with product) • Requires large space for equipment (installation of storage shelves for work-in-progress) • Increases production lead time
Stockless	• Reduces the risk of product quality deterioration (infrequent contact with product) • Minimises space for equipment (unnecessary to install storage shelves for work-in-progress) • Reduces production lead time	• Requires many pieces of green machining equipment (large equipment investment) • Lowers equipment operation rate (in case of small-quantity production)

Table 1 Features of production systems using green machining (Courtesy SEI)

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Creating a green machining production line

In addition to successfully drilling complexly-arranged holes and channels, a further goal of the engineers at SEI was to establish the touchless, stockless, in-line machining of green compacts by syncronising compacting and green machining.

Igarashi stated that in a typical production line, the green machining process creates a buffer, as the green machining cycle time is longer than powder compacting and sintering cycle times. In practice, this results in an intermittent production run, with green compacts placed temporarily in stock, green machined, returned to stock and then sintered once the desired number of machined compacts has been reached.

An alternative to this is known as a stockless production system. Here, two or more green machining stations are incorporated in parallel to syncronise the compacting and machining stages. For this project, a stockless produciton system was selected by SEI as, although requiring a greater investment in green machining equipment, this method has numerous advantages compared with the intermittent option. The advantages and disadvantages of the two green machining systems are given in Table 1.

An outline of the stockless green machining production line established at SEI is shown in Fig. 8. The line incorporates a compacting press, several green machining systems, 2D laser code printer (Fig. 9), sintering furnace and sizing press. The production line is automated and touchless, in which all devices are interlinked and operated automatically.

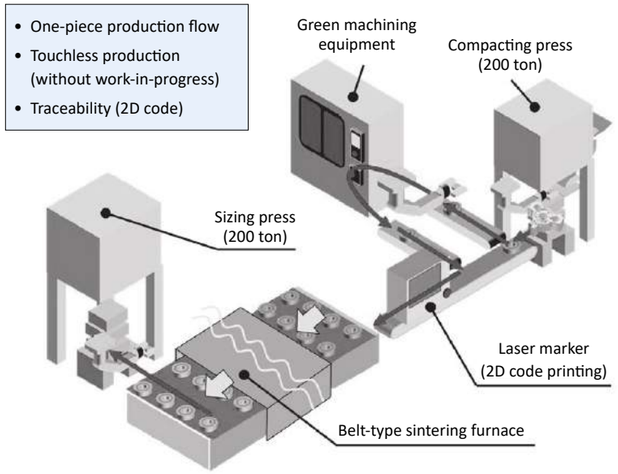

Fig. 8 Schematic of the stockless production line where powder compaction and green machining are synchronised (Courtesy SEI)

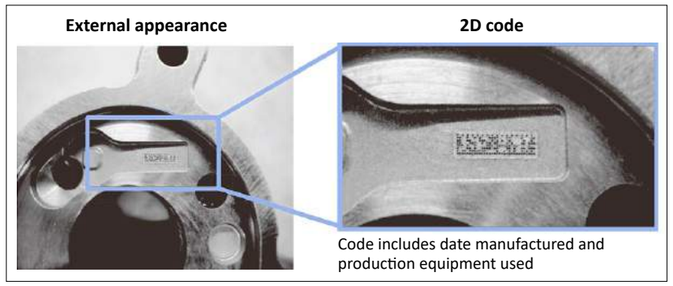

Fig. 9 A two-dimensional code is printed on each product immediately after the green machining stage. It provides the manufacturing history of the product including the date and production equipment used at each stage (Courtesy SEI)

High volume production of advanced VVT parts

Igarashi confirmed that the team of engineers at SEI had successfully constructed a production line to manufacture high volume complex VVT components. The use of green machining, with optimised machining conditions and cutting tool geometries, had made it possible to effectively and economically incorporate numerous holes and inner diameter grooves in the final part.

The automated production line has provided a touchless and stockless process, with in-line green machining and a 2D code ensuring product traceability.

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