VOL. 6 NO. 2
SUMMER 2017

POWDER METALLURGY REVIEW

PM AUTOMOTIVE TEARDOWN

LOW VOLUME PART PRODUCTION

PLATING OF PM PARTS

www.pm-review.com

Published by Inovar Communications Ltd

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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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Subscriptions
Powder Metallurgy Review is published on a quarterly basis. It is available as a free electronic publication or as a paid print subscription. The annual subscription charge is £95.00 including shipping.

Design and production
Inovar Communications Ltd.
ISSN 2050-9693 (Print edition)
ISSN 2050-9707 (Online edition)

This magazine is also available for free download from www.pm-review.com

www.pm-review.com

POWDER METALLURGY REVIEW

Automotive sector can still provide opportunities for PM

The weight of Powder Metallurgy components found in vehicles varies greatly between different models, manufacturers and geographical regions. A trend towards smaller power plants and the development of electric hybrid technologies also has an impact on the conventional automotive applications for PM.

To reveal the current usage of PM in the automotive industry, engineers at Höganäs have undertaken a project to teardown a range of modern vehicles from major global regions of auto production. The results, as can be seen in the article beginning on page 41, not only identify existing usage but also highlight many applications that still offer the potential for conversion to PM.

Those wishing to discover the latest developments in PM technology should also head to POWDERMET2017 in Las Vegas, USA, June 13-16. The event features over 200 technical presentations and the largest PM exhibition in North America. Visit our booth #428 and pick up your free copy of *PM Review*, *PIM International* or *Metal AM* magazine.

Paul Whittaker
Editor, *Powder Metallurgy Review*

Cover image
These PM parts have been treated with Sinter Surface Solutions, a process that impregnates the part and allows successful plating (courtesy Holzapfel Group)

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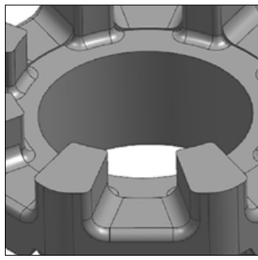
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To submit news for inclusion in *Powder Metallurgy Review* contact Paul Whittaker, paul@inovar-communications.com

GKN to purchase Turkish PM part manufacturer Tozmetal

GKN plc has announced it is to acquire Tozmetal Ticaret Ve Sanayi AS, located in the Istanbul Ataturk Free Trade Zone in Turkey. Tozmetal is a Powder Metallurgy parts manufacturer which focuses much of its output on hydraulic pump components for the European automotive market and reported sales of €24 million in 2016.

Speaking on the acquisition, Peter Oberparleiter, Chief Executive of GKN Powder Metallurgy, stated, "We are very excited to welcome Tozmetal into GKN Powder Metallurgy. Tozmetal is a well-run business that will complement our broad presence in the powder metals market."

The Tozmetal facility in Istanbul

Tozmetal operates out of its 6,000 m² Istanbul facility. The site houses around 45 mechanical, hydraulic and eccentric presses and five sintering surfaces. Annual capacity is currently reported to be 2000 tons, with exports accounting for 85% of production.

The company is an approved manufacturer for many automotive firms in Europe, listing customers such as VW Audi Group, GM Opel and Renault. With its product range of over 1,500 parts, GKN's acquisition of the company is expected to dramatically increase its presence in the European auto market.

www.gkn.com
www.tozmetal.com

Kobe Steel acquires Quintus Technologies

Kobe Steel, Ltd., Tokyo, Japan, has announced its acquisition of Swedish-based Quintus Technologies AB from private shareholders led by US private equity firm Milestone Partners. The total purchase price was reported at $115 million. Quintus is now a wholly owned subsidiary of Kobe Steel.

Quintus manufactures a range of hot and cold isostatic presses (HIP/CIP) and has achieved a strong presence in Europe, the USA and China. Its isostatic presses are used in the manufacture of high-performance products, particularly in the aerospace sector where they are used for aircraft parts, power generation and turbine blades.

The acquisition of Quintus is expected to enable Kobe to expand its line-up of HIP products and enter new growth markets.

www.kobelco.co.jp

Miba to take full ownership of Brazil's Mahle Metal Leve Miba Sinterizados

Miba AG, headquartered in Laakirchen, Austria, will acquire full ownership of Brazilian Powder Metallurgy component manufacturer Mahle Metal Leve Miba Sinterizados (MMLMS) as of June 30, 2017, the company reports. With a production volume of 6,500 tons per year, MMLMS is reported to be the biggest producer of sintered components in Latin America. The company produces a wide range of PM parts including bearing caps, components for oil and water pumps, belt pulleys, chain sprockets, gear shift forks, synchroniser hubs and rings, and compressor components.

To date, Miba AG has held a 40% stake in the joint venture with Germany's Mahle Group. The company will now operate as Miba Sinter Brazil (MSB). As a result of the acquisition, Miba Group will be positioned on four continents with its own plants and employ more than 6,200 employees globally.

MSB employs 340 people at its Indaiatuba site, near São Paulo, Brazil, and specialises in producing sinter components for the South American automotive industry and global compressor industry. The company reportedly generates an annual revenue of around €30 million. Miba has held an interest in the company since 1998 through a joint venture with the German Mahle Group. In 2013 Miba increased that interest from 30 to 40% and, as of June 2017, Miba will own 100% of the venture.

"By acquiring all the shares in MSB, we are consistently following our path of global growth," stated F. Peter Mitterbauer, Chairman of the Management Board of Miba AG. "Miba's strategic goal is to operate production sites around the world where we see opportunities for our customers, and ourselves, to grow. Having a global presence is particularly essential in the automotive industry in order to play a strong role in the global markets."

The automotive market in Brazil, and in the whole of Latin America, has been extremely challenging and volatile over the past years. However, according to Mitterbauer, "Miba AG's shareholding in MMLMS has taught us about the Brazilian and the entire South American automotive market, which we have been following for almost 20 years. And we are convinced that the market will enjoy sustained, positive development after difficult years."

www.miba.com

Embassy Powdered Metals to acquire American Sintered Technologies

Embassy Powdered Metals, Inc, Emporium, Pennsylvania, USA, will acquire American Sintered Technologies (AST), also based in Emporium, and retain both companies' existing workforces, the company has announced. The acquisition is reported to be part of a long-range business plan to expand operations for the company. Embassy will invest $3,050,000 in the purchase, which includes AST's real estate, machinery and equipment assets. Embassy has committed to retaining a combined total of 96 full-time employees from the two companies over the next three years.

"It was a natural perfect fit for our growing business here in Emporium," stated Steve Aharrah, President of Embassy. "Both privately held companies were locally built on foundations of community partnership and shared success with customers, employees and vendors. These commonalities will help produce a seamless integration of our companies' philosophies and services."

To assist with the acquisition, Embassy received a funding proposal from Pennsylvania's Department of Community and Economic Development, including a $250,000 Pennsylvania First Program grant and $32,400 in WEDnetPA funding for employee training. The company has also been encouraged to apply for a $1,250,000 low-interest loan from the Pennsylvania Industrial Development Authority.

Founded in 1996, Embassy Powdered Metals, Inc is a privately held and operated powdered metal manufacturing facility. Prior to its acquisition of AST, the company employed approximately 50 full-time staff.

www.embassymetals.com

GKN expects continued growth for 2017

GKN plc has reported that the global engineering group achieved good overall organic sales growth in the first quarter 2017 (January–April), with the automotive market performing better than expected.

"GKN delivered a good performance in the first quarter. The encouraging growth rate achieved to date may not be sustained as the year progresses and comparators get tougher, nevertheless, we expect 2017 to be another year of growth," stated Nigel Stein, GKN's Chief Executive.

GKN Powder Metallurgy has seen organic sales growth in line with global auto production. The growth includes a direct pass through of higher raw material prices, which have reduced margins slightly.

www.gkn.com

UC Rusal and Runaya Metsource to produce aluminium powders in India

UC Rusal, headquartered in Moscow, Russia, has entered into a partnership with Runaya Metsource, Mumbai, India, to create a joint venture on an equal basis. The joint venture will involve the building of a facility in India, specialising in the production of high-technology aluminium powders and pastes with a wide range of applications, including in key innovation areas such as Additive Manufacturing and solar energy.

Following commencement of production at the facility, products produced by the joint venture will be sold primarily in the Indian, South-East Asian and Middle Eastern markets, where metal powder demand is growing rapidly.

Alexey Arnautov, Rusal's Director for New Projects, stated, "Rusal's strategic priority includes the increase in production and sales of high value added products, including the creation of joint ventures. A combination of Rusal's long-lasting experience in production of aluminium powders and pastes as well as Runaya Metsource's strong position as a local player create solid competitive advantages for the JV and is an excellent foundation to penetrate the market."

"Runaya's strategy is to enter businesses focusing broadly on material sciences and manufacture products with high technology applications through alliances and partnerships with global leaders," added Naivedya Agarwal, CEO Runaya Metsource and designate Managing Director of the Joint Venture. "I'm delighted with this joint venture with Rusal, which will innovate and produce high-end aluminium-based products for fast growing global and regional markets."

The project is expected to begin this year and commence commercial production in 2018.

www.rusal.com

Kennametal reports positive third quarter results

Kennametal Inc. has reported positive results for its 2017 fiscal third quarter ended March 31, 2017. Sales were $529 million, compared with $498 million in the same quarter for 2016. The company saw an overall sales increase of 6%, driven by 5% organic growth and 2% increase due to more business days, partially offset by a 1% unfavourable currency exchange impact.

Operating income was $58 million, compared to $27 million in the same quarter last year. Adjusted operating income was $68 million, compared to $39 million in the prior year quarter. According to Kennametal, the increase in adjusted operating income reflects incremental restructuring benefits, organic sales growth, higher absorption and productivity and favourable mix, partially offset by higher performance-based compensation and the negative effects of higher raw material costs. Adjusted operating margin was 12.8% in the current period and 7.8% in the prior year period.

"This quarter's results exceeded our expectations by almost every metric," stated Ron De Feo, Kennametal's President and CEO. "Simply stated, revenue grew and costs declined, reflecting continuing progress with the work we began nine months ago. Revenue grew 6%, of which 5% was organic growth, and every region grew. The Widia segment posted quarterly profit for the first time with an adjusted operating margin of 2.3%. The Industrial and Infrastructure segments posted adjusted operating margins of 15.1% and 12.3%, respectively. These are strong numbers, and we are pleased to see the improvements in both sales and margins this quarter."

"Very little of this progress reflects the structural benefits from the modernisation and End-to-End initiatives that we have planned," De Feo continued, "nor the benefits from the ongoing product and process simplification initiatives. The results of those programs will accrue to the Company over the next two to three years. This is a time of real change at Kennametal and we are excited to continue the work of improving the Company."

www.kennametal.com

JFE Steel and Baosteel Metal to make metal powder in China

JFE Steel, headquartered in Tokyo, Japan, will partner with China's Baosteel Metal to produce metal powder in China, reports *Nikkei Asian Review*. JFE Steel, a unit of JFE Holdings, is reported to be the first Japanese steelmaker to bring expertise on the production of high-value-added iron powder to China.

The announcement follows the formation of a 50-50 venture with China's Baosteel Metal, a subsidiary of Baowu Steel Group. Beginning in 2018, the joint venture will manufacture premixed iron powders uniformly coated with copper and nickel alloys. An investment of approximately 109 million yuan ($15.7 million) will be used to construct a new factory in Shanghai equipped with the technology to mix alloyed metals with externally procured iron powder. It is reported that the new facility will have an annual production capacity of 30,000 tons.

www.baosteel.com
www.jfe-steel.co.jp/en

Johnson Electric to increase ownership in Halla Stackpole Corporation to 80%

Johnson Electric Holdings Limited, Hong Kong, China, has announced a definitive agreement to acquire an additional 50% equity interest in Halla Stackpole Corporation (HSC), Ochang, South Korea for 93.9 billion Korean Won ($83.8 million). Established in 2008, HSC is a joint venture between Halla Holdings Corporation, Korea, and Stackpole International, Canada.

Since the acquisition of Stackpole International by Johnson Electric in October 2015, HSC has been a 30% owned affiliate of the Johnson Electric Group. Upon completion of the acquisition of an additional 50% equity interest from Halla Holdings, Johnson Electric's ownership interest in HSC will increase to 80%.

HSC supplies Powder Metallurgy components to the Asian automotive industry. The company reported consolidated revenues for the year ended December 31, 2016, of 158 billion Korean Won (approximately US$141 million). The business employs over 500 people and operates two production facilities, one in Korea and one in China.

"This is an attractive opportunity to increase the group's exposure to the rapidly growing powder metal market in Asia. Stackpole International is already a recognised market leader in the powder metal industry in North America and this complementary investment provides a platform for accelerating sales growth and strengthening the Johnson Electric Group's position as a global supplier to key engine, transmission, suspension and steering applications," stated Dr Patrick Wang, Chairman and Chief Executive of Johnson Electric.

The Halla Stackpole facility in South Korea

HSC manufactures a range of Powder Metallurgy components found in automobile engine, transmission, steering, suspension and compressor applications.

The transaction is expected to close in the second quarter of 2017, subject to customary conditions including obtaining applicable regulatory approvals.

www.johnsonelectric.com
www.hallastackpole.co.kr

Record sales at Miba as revenue exceeds €750 million

Miba AG, headquartered in Laakirchen, Austria, has reported record revenue of €752 million in its fiscal year 2016 -2017 (1/2/16 to 31/1/17). The company also stated it has invested over €100 million in property, plant and equipment and in research and development.

"We never deviated from our growth course even during the crisis years of 2008 and 2009. Despite this difficult time, we were only slightly late in meeting our revenue target of €750 million," stated F. Peter Mitterbauer, Chairman of the Management Board of Miba AG, "Under the Miba 2020 – Dynamic Evolution strategy, we have set ourselves new and again very ambitious goals. We are aiming for consolidated revenue of €1 billion by 2020."

In the past fiscal year, the Miba Group grew primarily in the automotive segment, stating it outpaced global increases in passenger vehicle production by a clear margin. This was due to the fact that many manufacturers are now replacing components with Miba's PM technologies.

The company added that the global truck market presented a mixed picture, with regional performance varying considerably in 2016. In the EU the market for heavy trucks remained positive and in China there were strong increases. In North America, on the other hand, sales figures declined. The global markets for agricultural commercial vehicles, construction machinery and mining equipment seem to have recovered slightly in 2016 following the downturn in recent years.

F. Peter Mitterbauer, Chairman of the Management Board of Miba AG

In power electronics, there was some noticeable restraint in the industrial sector, but Miba was able to leverage the opportunities arising from the growth in electromobility, wind power and High-Voltage Direct Current (HVDC) transmission. "Our broad portfolio of products and services proved its worth again in the past fiscal year. This enabled us to leverage the opportunities available to us and continue growing in spite of a challenging market environment," added Mitterbauer.

www.miba.com

Hilti Group announces Fischer as Chairman of the Board

Hilti Group, headquartered in Schaan, Liechtenstein, has announced that Heinrich Fischer has been appointed Chairman of its Board of Directors. Fischer will succeed Pius Baschera, who will stay on the Board of Directors and take over as Speaker of the Martin Hilti Family Trust, sole shareholder of Hilti Corporation.

Prior to his appointment as Chairman, Swiss-born Fischer has served as member of the Board of Directors for ten years, as well as serving on the Board of Directors for Tecan AG, Orell Füssli AG (Chairman) and Sensirion AG. From 1996 to 2007, he was Chief Executive Officer of Saurer AG, Arbon, Switzerland.

As Chairman of the Hilti Group, expediting the achievement of the Group's strategic objectives will be his first priority: "I am convinced that we are already well-positioned today to successfully implement our Champion 2020 Strategy, to grow substantially and to generate sustainable value through differentiation and market leadership," Fischer stated. "To help shape this journey as Chairman of the Board of Directors is a gratifying and challenging task that I am very much looking forward to."

www.hilti.com

AMES opens new Chinese production site

AMES, Barcelona, Spain, has expanded operations with the opening of a new production site in Wuhu County, near Shanghai, China, the company states. The new factory, which incorporates a production area of 14,500 m² and will employ a workforce of 250 people, officially opened on March 28, 2017.

According to AMES, the new plant will manufacture structural sintered components for the Chinese automotive sector, as well as making it possible for AMES to manufacture parts for other Asian markets depending on demand.

The factory was reported to be in the preparatory stages, with industrial machinery start-up and staff training underway. Production was expected to begin in full in May 2017 following client approval.

AMES's decision to expand operations into China, the company stated, follows a trend of dramatic automobile production growth in the region and an increased need among China-based clients for a supply of locally built high-technology components.

www.ames-sintering.com

Nippon Piston invests in Indian car and motorcycle market

Nippon Piston Ring, Tokyo, Japan, has invested 1 billion yen ($8.5 million) to increase its output of valve seats by 30% in India, reports *Nikkei Asian Review.* The investment follows a trend of increased car and motorcycle production in the country – in 2015, India saw a 5% overall rise in car production, while motorcycle production reached 18.83 million units, compared to Japan's 500,000 units.

The investment follows the building of Nippon Piston Ring's newest factory in Karnataka, India, which began operation in January 2017. The 8,000 m² plant has a monthly capacity of around three million valve seats, 30% higher than previous levels

Nippon Piston Ring created its Indian manufacturing subsidiary in 2011 and operated from a leased Karnataka factory to produce valve seats for Honda Motor and Yamaha Motor motorcycles as well as for Suzuki Motor cars. The company will now transfer production to the new Karnataka site.

By fiscal 2017, Nippon Piston has expressed its aim to boost sales by 5% from its fiscal year 2015 levels to 55 billion yen, of which around 60% will come from overseas, according to its medium-term management plan. While Japanese sales are expected to fall on the year, the component maker plans to offset the drop with sales growth abroad.

www.npr.co.jp/english

Sandvik reports increase in operating profit for 2016

Sandvik AB, Stockholm, Sweden, has published its Annual Report for 2016. The company stated that a number of customer segments were affected by a challenging macro-economic situation in 2016, reporting that order intake across all business areas amounted to SEK 84,233 million, a year on year decrease of 1% at fixed exchange rates for comparable units. Operating profit for 2016 was, however, reported to be SEK 9,657 million, up from SEK 6,062 million in 2015 and corresponding to 11% of revenue, compared with 7% in the previous year.

According to the report, a new strategic direction established in 2016 focused on decentralisation, moving profit and responsibility to product areas and establishing new management teams for many of its businesses. Sandvik stated that it altered its business area structure to focus on core operations. A key aspect of this was the merger of Sandvik Mining and Construction into one business, renamed Sandvik Mining and Technology.

The divestment process of Sandvik's Mining Systems, Hyperion and Process Systems continued throughout the financial year. In 2017, the company has reported its plans to invest in and pursue new acquisitions in line with its core business areas. Sandvik's board of directors also reported that it will continue to focus on its core capabilities going forward, such as material and application knowledge.

Following movements in metal prices and successful results in the Materials Technology sector, the year also saw Sandvik initiate work towards its new Additive Manufacturing segment, which began operation in January 2017. This new business is intended to fully commercialise Sandvik's position in the AM market.

"We are on track to fulfil our ambitious targets by making continuous improvements throughout our business to achieve stability, profitability and growth. Our increased decentralisation and the changes we are now focusing on are the foundation for our capability to deal with anticipated market trends and variations in the business climate. We will continue to be a market leader, secure even better results and market shares, as well as continue to be an attractive company to work for and to own," stated Sandvik President and CEO Björn Rosengren.

www.sandvik.com

Harper International announces strategic partnership with Ferrite Microwave Technologies

Harper International, Buffalo, New York, USA, has formed a strategic partnership with Ferrite Microwave Technologies (FMT), Nashua, New Hampshire, USA, a provider of 915 MHz industrial microwave systems. Through the partnership, Harper will utilise FMT's high power microwave heating technology to complement its own product portfolio of traditional gas and electric fired furnaces. According to Harper, this will equip its customers with access to a broader range of options and expertise.

FMT has patented several microwave technologies enabling advanced microwave field distribution across a wide variety of materials, some of which will now be integrated into Harper's furnace systems. As commercial microwave use requires material specific equipment, Harper has expressed its hope that matching the engineering and design capabilities of FMT with Harper's furnace systems will provide customers with a distinct advantage for their unique processing requirements.

Charles Miller, President at Harper, stated, "Our cooperation with FMT is aligned with our commitment to provide customers with the ideal thermal processing method for their material production. Microwave can be a highly efficient and effective solution for a range of materials including ceramic and metal powders. To provide our customers with an expanded solution set via world class microwave components inside our proven furnace systems is a winning combination."

Inside an industrial microwave system

Peter Tibbetts, CEO of Ferrite Microwave Technologies, added, "Teaming up with Harper gives us access to material processing capabilities and expertise that will enable us to solve more complex heating problems for our customers. At FMT, we constantly strive to advance the science of industrial microwave processing. Partnerships with industry leaders like Harper open up new avenues of advancement that are very exciting."

www.harperintl.com
www.ferriteinc.com

Sacmi to present latest range of presses and furnaces at POWDERMET2017

Sacmi has announced it will present its latest range of presses and furnaces at POWDERMET2017, Las Vegas, USA, June 13-16, 2017. Of particular interest to the Powder Metallurgy industry is Sacmi's MPH800, the latest in the company's line of CNC hydraulic presses. According to Sacmi, the new 800 ton press has been specially engineered in order to grant the highest structural rigidity and mechanical reliability.

Sacmi reports that set-up times on the MPH800 have been minimised thanks to the company's automatic die-set change system, which allows production to restart in less than 30 minutes. As with Sacmi's other presses, the MPH800 is equipped with an Assisted Programming Interface which reduces press programming and tuning times. The integrated graphical interface automatically generates the best pressing curves based on the geometrical characteristics of the piece and allows operators to crosscheck the results with a user-friendly cycle simulator prior to starting production.

Sacmi will be at Booth 322 in the exhibition hall.

www.sacmiusa.com

Japan's PM industry reports slight fall in 2016 production

According to figures from Japan's Ministry of Economy, Trade and Industry published in the Japan Powder Metallurgy Association's newsletter, total PM production, including structural PM parts, PM bearings, sintered friction materials, current collectors and other PM products, slipped by 1.5% in 2016, compared with 2015, to 93,121 tonnes. Of this total, 85,040 were structural PM parts (-1.4%), 6,227 tonnes PM bearings (- 0.9%), friction materials 596 tonnes (-9.7%), current collectors 65 tonnes (-12.2%), and others 1,193 tonnes (-2.9%). Total sales value of all PM materials produced in Japan in 2016 reached Yen 155,441 million ($1.382 billion), down 3.2% on the previous year.

By far the most important area of applications for both structural PM parts and PM bearings in Japan is the automotive industry. In 2016, the automotive sector consumed 80,405 tonnes, or 94.5%, of total PM part production, and 4,029 tonnes, or 64.7%, of PM bearings were also delivered to Japan's automotive producers, with the balance going to other sectors of engineering. As can be seen in Fig. 1, structural PM part production and sales in Japan reached a peak in 2007 when more than 130,000 tonnes were produced. Fig. 2 shows production and sales trends for PM bearings in Japan since 1980.

www.jpma.gr.jp

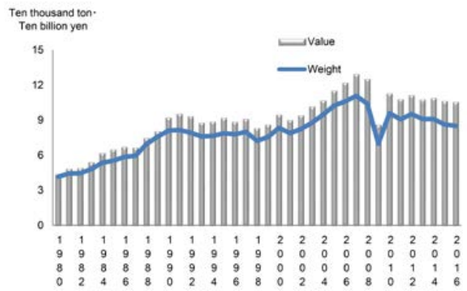

Fig. 1 Structural PM part production in Japan

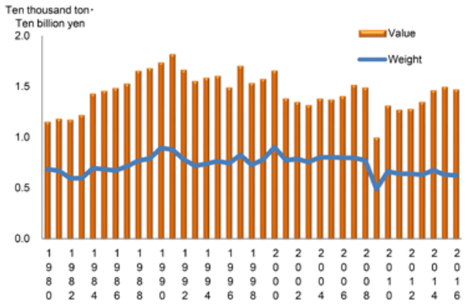

Fig. 2 Production of PM bearings in Japan

New production line for medical engineering products at Plansee

Plansee will invest €10 million in the construction of a new production line for medical engineering products at its Breitenwang facility in Reutte, Austria, the company has announced.

The new project was launched officially on March 23, 2017, with a presentation on the role of Plansee's components in modern medical devices by Dr Andreas Lackner, Executive Director, Plansee SE, in the presence of Austrian Chancellor Christian Kern.

The Reutte facility is Plansee's largest production site and has been manufacturing medical engineering products, such as those installed in X-ray machines, CT scanners and other applications, for more than 60 years. Plansee's new production line will offer the company a highly automated and networked production process, which is expected to bring the company into line with the demands of Industry 4.0.

"We want to continue to produce medical engineering products highly competitively in the heart of Europe in the years to come," stated Bernhard Schretter, a member of the Board of Directors of Plansee Holding AG. "Intelligent interfaces, end-to-end product coding and tight processes will permit considerably shorter delivery times."

Plansee's new production line was launched with a presentation on the role of Plansee's components in modern medical devices by Dr Andreas Lackner (Courtesy Plansee)

The new production line, which is expected to enter use within 12 months, is part of a total €46 million investment into the Breitenwang/Reutte site over the financial year 2016/17, with investments on a similar scale planned for the current year.

www.plansee.com/en

Global automotive industry optimistic for continued growth in 2017

Based on strong growth in production and sales of automobiles in the first quarter of 2017 in most of the key regions around world, there is optimism that this year will see continued gains for the global automotive industry. According to Wards Auto, some 23.92 million vehicles were sold globally in the three months to March 2017, up 5.3% on the same period in 2016.

A surprising result came from South America, where many countries continue to suffer from economic downturns. Despite this, total South American vehicle sales soared by 14.1% to 339,000 units in March 2017, bringing a first quarter total of 899,000 units, up 9% on the same quarter of 2016. Vehicle production in Brazil, the continent's biggest car producer, was up by 24% to 609,844 units in the period.

North American vehicle sales in the first quarter came in below expectations, dipping 0.5% to 4.92 million units. However, total car and light vehicle production in the region was up 1.5% in the last quarter to 4.615 million units with Mexico gaining by 18.4% to reach 996,273. Both the USA and Canada saw declines in vehicle production with the US slipping by 1.9% to 3,017 million and Canada down 4.5% to 601,443.

The Western European car market ended the first quarter up more than 7% on the same period in 2016, recording 3.9 million new registrations. All of the five largest individual markets expanded, with Italy enjoying the strongest growth at 18%. Double digit growth was also recorded in Spain (+13%) and Germany (+11%), with the United Kingdom up 8% and France 7%. Total light vehicle production in the EU was up 3% to 5,016 million units in the first quarter of 2017.

Russia vehicle sales grew by 8.4% in March 2017 to 145,000 units, pushing the year-to-date total just ahead of the same period in 2016. Russian vehicle production was up 1% to 322,464 units in the quarter.

In the Asia-Pacific region, sales for the first quarter were 6.9%, ahead of the same period in 2016, with 11.37 million units or 47.5% of the global market. China performed strongly again in the first quarter with production and sales of passenger cars rising to 7.133 million and 7,002 million respectively, representing increases of 8% and 7% year-on-year. Japan reported a healthy increase of 7.9% in passenger car production in the first quarter to reach 2,200 million units; with total vehicle production, including trucks and buses, up 6.5% to 2,545 million. Vehicle sales in Japan increased by almost 8% in the quarter to March, reaching over 1.3 million. In India, sales of passenger cars were up 11%, when compared with the same period last year, at 803,200 vehicles. In the reporting period April 2016–March 2017 production of passenger cars and commercial vehicles in India increased by 5.8% to 4,502 million of which 3,791 million were cars.

Japanese carmakers developing gasoline engines to compete with electric vehicles

Japanese carmakers are looking to further improve gasoline engine efficiency and output to enable conventional automobiles compete with electric and eco-friendly powered vehicles, reports *Nikkei Asian Review*.

Mazda is reported to be adding variable displacement and mild hybrid systems to its current engines at the end of 2017. The variable displacement technology idles some of the engines cylinders when they are not needed and will be applied to larger engines found in Mazda's CX-5 sport utility vehicle and other models. Mild hybrid systems incorporate a small electric motor to support the gasoline engine, decreasing engine load, and will be employed in a variety of models. The addition of these systems is reported to improve fuel economy by around 10%.

Nissan has reported plans to install variable-compression turbo engines in its Infiniti brand in 2018, with a view to expanding the technology to cover the entire Nissan range in future. An engine typically has a fixed compression ratio of around 10-1 to compress the gasoline-air mix in cylinders. Nissan's variable-compression engine can change the top dead centre of piston movements to result in ratios ranging between 8-1 and 14-1.

Higher compression ratios raise combustion efficiency but can also increase the likelihood of engine knock, in which abnormal combustion causes body vibrations. The variable-compression engine will select the optimal compression ratio while balancing fuel consumption and output. The company has stated that it expects to see a 27% rise in fuel efficiency as a result of the change.

Toyota Motors has also announced its plans to roll out a powertrain this year which will improve fuel economy by around 20%, through better combustion efficiency and reduced components. Toyota has said it expects to use this type of powertrain in over 60% of its products by 2021 and is considering supplying the system to other companies.

Despite the steady increase in electric and hybrid engine manufacture, a report by IHS Automotive has predicted that in 2028 gasoline engines will still account for 48% of automobile power sources, with diesel engines at 12%.

www.nissan.co.uk
www.mazda.co.uk
www.toyota.co.uk

SMP introduces new range of compact chokes for drive technology applications

German-based manufacturer Sintermetalle Prometheus GmbH & Co KG (SMP) displayed its latest range of chokes for frequency converters and other drive technology applications at PCIM Europe 2017, May 16-18. The compact, low-loss, powder composites chokes are reported to have a space-efficient design and good electromagnetic capability characteristics.

The new compact chokes have been installed in frequency converters at the input, where they provide power recovery, and at the output, where they act as filter chokes. They have also been installed in frequency converters at the internal DC links, as both single and common-mode chokes. The components incorporate an efficiency-increasing core of powder composites with low magnetostriction, while an encapsulated design ensures that the components emit only low-intensity stray fields- a requirement in frequency converters which allows other components to be placed in close proximity to the choke without the risk of magnetic interaction with the choke.

The new compact chokes use in-house developed powder composite materials with a reported saturation induction of up to 2 Tesla. They are available in dimensions ranging from 19 mm–300 mm and weighing from 0.05 kg–130 kg, and up to temperature class H (180°C). Depending on the application, protection classes up to IP66 are available. All components are RoHS and REACH compliant and CE and EAC certified, and the materials used are UL-listed.

SMP chokes are available with protection classes up to IP66

SMP was founded in 1982 and today employs about 150 people. With a key focus on research and development, SMP's product range includes low-loss inductive custom components based on in-house-developed powder composites.

www.smp.de

ZF to invest €100m at its Hungarian facility

ZF Hungária, a Hungarian subsidiary of German auto parts manufacturer ZF Group, has announced its plan to invest HUF 31 billion (€100 million) in its plant in Eger, Northern Hungary, according to a press statement issued by Hungary's Ministry of Foreign Affairs and Trade.

The Hungarian government will support ZF Hungária's investment with a grant of HUF 6.7 billion (€21.5 million). Péter Szijjártó, Hungary's Minister of Foreign Affairs and Trade, has stated that the investment will create at least 770 new jobs and bring cutting-edge technology to the country.

The new investment will expand the Eger plant's production activities to include the manufacturing of eight-gear automatic transmission systems, for local use and for global export, which the Ministry states could boost Hungarian export volume by HUF 200 billion (€647 million) annually.

"Countries that can convince companies that employ state-of-the-art technology to invest in them will be strong in the future; those that are incapable of doing so will be the losers of the new world economic order," stated Szijjártó. 2016 saw record production in the Hungarian automotive industry, valued at HUF 7,874 billion (€25.5 billion). In his statement, the Minister noted that the automotive industry is a major driver of Hungarian economic growth. "Hungary has so far been an ideal production location," he added, "and the task now is to become an ideal location for R&D."

ZF Hungária's Eger plant opened in January, 1996, and currently employs 854 staff. The plant supplies automotive parts to manufacturers globally, including Volvo, MAN, Renault, Nissan, Volkswagen, Volvo, Leyland, Hyundai and Neoplan.

www.zf.com

Höganäs announces opening of new Indian technology centre

Höganäs India has announced the opening of a new technology centre in Pune, India. Launched in April 2017, the ITEC centre will offer support to Höganäs's customers in the Indian market.

The facility offers data generation facilities for fatigue and tribology, a water treatment demonstration centre and a laboratory. Initially, it will offer analytical support to customers on site and will also employ a staff of on-call ITEC engineers for external customer visits.

Melker Jernberg, Höganäs President and CEO, stated, "There is a great scope for expanding the facilities and our offerings to suit the customer's needs."

www.hoganas.com

Japan's Powder Metallurgy companies report mixed full year results

Five of Japan's leading companies with involvement in Powder Metallurgy production recently reported their full year financial results for the period April 1, 2016 to March 31, 2017. In line with sluggish growth in Japan's automotive sector, which is by far the country's largest consumer of PM products, and the slight decline in overall Japanese PM production in 2016 (as reported on Page 18), it was not surprising that most of the companies reported a drop in overall sales.

Mitsubishi Materials Corp. (MMC) saw a further decline in consolidated net sales in the 12 months to end of March 2017, with an 8% drop to Yen 1304 billion ($11.77 billion). Operating profit was down 15.1% to Yen 59 billion ($539 million). Net sales at MMC's Advanced Materials & Tools division, which incorporates cemented carbide (hardmetal) tools, structural PM parts and PM bearings, high performance alloy products and superalloys, were reported to have dropped by 8.2% to Yen 143.4 billion ($1.3 billion). Operating profit dropped by 4.2% to Yen 11.7 billion ($90 million). The decline in this division was attributed to lower sales of cemented carbide products in Japan and overseas as well as lower sales of PM parts to the automotive sector.

www.mmc.co.jp

Hitachi Chemicals Co ltd, which includes the two main business segments of Functional Materials and Advanced Components & Systems, reported group sales up 1.4% to Yen 554 billion ($5 billion) for fiscal 2016/2017, with net income up 4% to Yen 40.7 billion ($367 million).

The Advanced Components & Systems division, which includes friction products, structural PM parts and PM bearings as well as vehicle batteries, printed circuit boards and diagnostic instruments, reported an increase of 1.6% in sales to Yen 283 billion ($2.5 billion) but with segment profit down to Yen 8.8 billion.

Hitachi Chemicals has PM production sites in North America, Indonesia, Singapore, China and Japan. The company recently reported that it plans to establish European development and production bases with a view to expanding sales into new regions.

www.hitachi-chem.co.jp

Sumitomo Electric Industries Ltd (SEI), based in Itami, Osaka, Japan, reported a 4.1% downturn in group sales to Yen 2814 billion ($25 billion) for the financial year ended March 31, 2017. However, group operating income was reported up by 4.8% to Yen 150.5 billion ($1.4 billion).

SEI's Industrial Materials & Others division is the third largest after the Automotive and Environment & Energy divisions, and includes the production of cemented carbides (hardmetals), PM parts, PM magnets, tungsten, molybdenum, heavy metal, thermal management materials and ceramics, as well as diamond tools and hardmetals produced at the wholly owned A.L.M.T. subsidiary.

The Industrial Materials & Others division saw overall full year sales decline by 2.7% in 2016/2017 to Yen 303.9 billion ($2.7 billion). However cemented carbide (hardmetals) sales increased by 12.7% to Yen 96.5 billion ($868 million) in the 12 months to March 31, 2017, and sales of Powder Metallurgy products increased by 17.9% to Yen 76.1 billion ($685 million) in the same period.

Sales at A.L.M.T. increased by 9.5% to Yen 42.4 billion ($382 million). SEI is forecasting sales for the Industrial Materials & Others division to reach Yen 340 billion ($3 billion) in the full year to March 31, 2018.

www.global-sei.com

Nippon Piston Ring Co Ltd, (NPR) based in Saitama, Japan, manufactures Powder Metallurgy products such as piston rings and valve seats used in internal combustion engines, metal injection moulded parts and dental implants. The latter are now produced in a new facility in Tochigi, established in 2015. NPR reported sales of Yen 52 billion ($469 million) for the fiscal year to March 31, 2017, showing a drop of just 0.2% on the previous year. Net profit was up 18.7% to Yen 2.9 billion ($26 million).

The company has manufacturing facilities in Japan, China, Indonesia, India and the USA.

www.npr.co.jp

Fine Sinter Co Ltd, based in Kasugai, Aichi Prefecture, Japan, manufactures a wide range of Powder Metallurgy components for numerous markets including the automotive sector, railroad industry and general industrial machinery applications. Automotive products are said to make up nearly 90% of sales.

Fine Sinter reported relatively flat sales for the fiscal year 2016/2017, down slightly to Yen 38.45 billion ($346 million) compared with Yen 37.48 in the previous year. However, the company saw net income grow by 7.5% to Yen 1.09 billion ($9.8 million). The company has six PM manufacturing facilities, with locations in Japan, China, Taiwan, Indonesia and USA.

www.fine-sinter.com

Freeman Technology establishes operations in Japan

Freeman Technology has announced the opening of a new office in Kobe City, Japan, and the appointment of Takashi Nishimura as Japanese Product Manager. Nishimura, who has over 10 years of experience working in the analytical instrumentation industry, will provide sales and customer support in the region.

The move follows a continued pattern of global expansion, R&D and applications development by Freeman. With over a decade of experience in powder flow and powder characterisation, Freeman aims to provide solutions for understanding powder behaviour in development, formulation, scale-up, processing, quality control or in any area where powders are utilised.

"Japan has always been an important market for Freeman Technology. Establishing our own direct operation there reflects the growth we have seen over the last decade, and our continued commitment to our customers," stated Tim Freeman, Managing Director.

www.freemantech.co.uk

World PM2018: Powder Metallurgy industry to meet in China

The 2018 World Conference on Powder Metallurgy, World PM2018, organised by China Powder Metallurgy Alliance (CPMA), will take place September 16 - 20, 2018, in Beijing, China. The event marks the first time that the World PM series has been held in China and will give those from outside the country an insight into PM, MIM and AM developments in one of the fastest growing economies in the world.

The conference will cover the full range of Powder Metallurgy topics, ranging from metal powder production and technology, powder compaction, sintering and post-processing to Metal Injection Moulding, cemented carbides, porous materials, Additive Manufacturing and the design and simulation of PM parts. The conference is expected to include over 500 presentations, giving a detailed overview of the latest developments in PM.

In addition to the conference there will be an exhibition held over four days. In excess of 200 international exhibitors are expected to participate, providing the ideal opportunity to network with material and equipment suppliers, part producers and end-users.

The World PM2018 exhibition is being managed on behalf of the organising committee by IRIS Exhibitions Service Co.,Ltd, organiser of the annual PM China exhibition series held in Shanghai each Spring. Exhibition sales enquiries should be addressed to Maggie Song, exhibition@worldpm2018.com. Those wishing to submit abstracts should note the submission deadline of October 15, 2017.

www.worldpm2018.com

PM database updated to include microstructures

The Global PM Database (GPMD) has been enhanced to include examples of PM microstructures, to assist PM parts manufacturers and end-users during the interpretation of PM microstructures. The new inclusion aims to help to build an appreciation of metallography as a powerful engineering tool for component design, new materials and quality control solutions.

The updated database will now allow the user to reference the microstructural phases in materials processed by conventional sintering, elevated temperature sintering, accelerated post-sintering cooling and more. The update also offers users guidance on specimen preparation and proper etchant selection. The data is displayed in a user-friendly format viewable in both tabular and graphic formats and it is hoped it will be of particular interest to design engineers in a range of industries.

www.pmdatabase.com

Ford invests $1.2 billion at three Michigan plants

Ford Motor Company will invest $1.2 billion in three of its manufacturing facilities in Michigan, USA, strengthening its position in the trucks and SUV markets.

The company plans to invest $850 million in its Michigan Assembly Plant to retool the plant to build the all-new Ford Ranger and Ford Bronco. Ford is also investing $150 million to expand capacity for engine components for several vehicles at Ford's Romeo Engine Plant, Michigan. The facility produces engines for Ford Super Duty, E-Series, Ford Shelby GT 350 Mustang and Shelby GT350R Mustang, along with components for F-Series, Explorer and Edge. The investment adds capacity and tooling for components for an additional engine when the plant begins its transformation in 2018.

The company also announced it will invest $200 million in an advanced data centre located at its Flat Rock Assembly Plant. This will be the second of two new data centres built by Ford in Michigan. Ford expects data usage to increase 1,000%, driven by manufacturing and business needs as well as new mobility services, such as more connected, autonomous and electrified vehicles.

www.ford.com

BorgWarner seeks access to global start-ups through investment in Autotech Ventures

BorgWarner, Auburn Hills, Michigan, USA, has announced a $10 million investment in Autotech Ventures, Palo Alto, California, USA, a venture capital fund that facilitates partnerships among financial investors, strategic corporate investors and start-ups focused on the future of transportation. Through this investment, BorgWarner hopes to pursue opportunities related to propulsion technologies and mobility areas outside of the company's current product portfolio.

"While we remain focused on providing industry-leading propulsion technologies, we expect this partnership to provide global access to new technologies and services, inside and outside of our core product strengths," stated Brady Ericson, BorgWarner's Chief Strategy Officer. "As with all of our recent investments, this contributes to our larger strategy to maintain a product portfolio that supports a cleaner, more energy-efficient world."

A key factor in the decision to invest in Autotech Ventures is the fund's ability to help BorgWarner easily adapt to the changing demands of the industry, the company reports. While trends from electrification and autonomy continue to evolve, BorgWarner's recent business moves have been focused on defining its position in the future automotive landscape.

"Over the last year and a half, we have taken great strides in the evolution of our company," said James R Verrier, BorgWarner's President and Chief Executive Officer. "In 2015, we acquired a leading electrical components maker in Remy, strengthening our position in electrified technologies. We earned a number of hybrid and electric customer contracts in 2016 and this continues in 2017, while commercialising new technologies, including our eBooster® electrically driven compressor and eGearDrive® transmission. All of these advancements are helping us develop the future of clean, efficient propulsion technologies."

Through its investment in Autotech Ventures, BorgWarner reports that it has been able to review hundreds of global start-ups involved in the future of ground transportation. In addition to the companies BorgWarner expects to invest in with Autotech Ventures, the automotive product leader plans to independently invest, collaborate and support a handful of start-up businesses.

"Industry priorities continue to change," added Ericson. "To be successful, we need to keep our fingers on the pulse of product trends and collaborate with innovative players across the world."

www.borgwarner.com

ASCO Sintering to showcase PM gears

ASCO Sintering Co., Commerce, California, USA, will exhibit its award-winning Powder Metallurgy gears at Gear Expo 2017, October 24-26, 2017, at the Greater Columbus Convention Center, Ohio, USA. Gear Expo is sponsored by the American Gear Manufacturers Association and showcases manufacturing and technology trends and innovations.

"ASCO's participation in Gear Expo helps reinforce our position as an acknowledged industry leader in the manufacture of award-winning highly complex powdered metal gears and planetary gear carriers through the application of a six sigma zero-defect philosophy," stated the company. ASCO has produced PM award winning products varying from miniature to complex geometries and assemblies.

The company's latest PM gears will be on display at Booth 207 in Exhibit Hall E, with sales and engineering management staff in attendance to discuss their design and application.

www.ascosintering.com
www.gearexpo.com

MPIF to form trade association for the metal Additive Manufacturing industry

The Metal Powder Industries Federation (MPIF), Princeton, New Jersey, USA, has announced its intention to form a trade association for the metal Additive Manufacturing industry. An organisational meeting will be held at the conclusion of its AMPM2017 conference on June 16 at the Bellagio Hotel, Las Vegas. Manufacturers of metal AM products, precursor materials and equipment manufacturers that support the metal AM industry are all welcome to attend.

As with existing MPIF affiliated associations, the tentatively named Association for Metal Additive Manufacturing (AMAM)'s main mission would be to increase the visibility and stature of metal AM within the industrial community and, in the process, enhance the metal AM industry's opportunities for continued growth. MPIF considers this a logical connection and has complete support for such an association from the Federation's Board of Governors.

The MPIF stated that the association is being proposed because:

- Metal AM represents a natural relationship to Powder Metallurgy technology
- MPIF is already well established as the organisation representing the worldwide interests of virtually all facets of PM technology
- MPIF has in place associations with combined parts manufacturing and supplier-base organisations
- Overseas members recognise and endorse MPIF as a highly respected international trade organisation.

The MPIF believes that of all organisational options, the trade association has the greatest credibility and acceptance as being representative of an industry and its technology. By becoming a trade division of MPIF, AMAM will benefit from the well-established reputation and high regard with which this organisation is held by the government, the Department of Justice and the engineering public. Other benefits of association will be discussed at the organisational meeting.

Those interested should contact Jim Adams: jadams@mpif.org.

www.mpif.org

Hagen Symposium to focus on 'Powder Metallurgy - Key to Mobility'

The 36th Hagen Symposium on Powder Metallurgy, to be organised by the Fachverband Pulvermetallurgie (FPM) in Hagen, Germany, November 30 to December 1, 2017, will discuss the use of PM as a key manufacturing technology in transportation industries such as the automotive and aerospace sectors.

In addition to presentations on developments in sintered steels and fully dense powder forged components for conventional fuel-efficient vehicles with internal combustion engines, there will also be a focus on functional PM components for electric vehicles and developments in PM superalloys and light metal alloys used in the aerospace sector.

A number of presentations will feature Additive Manufacturing used for series production of alloy components for transportation, the development of PM materials in fuel cells used to power trucks and in lithium batteries, as well as the Metal Injection Moulding of recycled NdFeB powder to produce permanent magnets.

www.pulvermetallurgie.com

New EPMA Club Project to explore high temperature sintering

The European Powder Metallurgy Association (EPMA) has announced it will launch a new Club Project focused on High Temperature Sintering (HTS) and dealing with the analysis of commercially available alloys, their processes and properties. The project will be coordinated in partnership with an industrial consulting group (Dr Volker Arnhold and Dr Vladislav Kruzhanov) and the Department of Industrial Engineering at the University of Trento, Italy.

By partnering players from across the supply chain, the EPMA has expressed its hope that the five-month project will be a driving force for the Powder Metallurgy industry to analyse the best commercially available alloy system for HTS and to compare several existing furnace concepts.

The key steps of the project will be:

- Manufacturing test parts from several commercial alloys,
- Sintering in industrial furnaces
- Testing several mechanical and dimensional properties for quick evaluation
- Evaluation of experimental results and production of a Final Report

Prospective participants can request more information by contacting Dr Olivier Coube (oc@epma.com), or by visiting the EPMA's project website.

www.epma.com/projects

Sandvik scientists rewarded for development of materials suited to extreme temperature applications

The 2017 Wilhelm Haglund Medal for Product Developer of the Year has been awarded to Roger Berglund, Bo Jönsson, Thomas Lewin and Krister Wickman from Sandvik Materials Technology for the development of new materials that can cope with extreme temperatures. The medal was presented at Sandvik's 2017 Annual General Meeting.

"There are many people at Sandvik who invest much energy in developing new solutions to make our customers more successful based on their needs, and we are highly honoured to receive the prestigious Wilhelm Haglund Medal for our efforts," stated Bo Jönsson.

The team developed two materials, Kanthal® APM and Kanthal APMT™, which the company says has resulted in a paradigm shift in thermal technology and the development of a number of new products and applications.

Conventional materials can have excellent oxidisation resistance, but a relatively low high-temperature strength, which limits applications in designs with low mechanical load. By using a Powder Metallurgy process, the team discovered a method to add billions of small particles to the metal, which dramatically increases the strength at high temperatures. The combination of characteristics in the new material is therefore said to be completely unique and revolutionary.

"The material enables substantially increased productivity for customers, at the same time as

Thomas Lewin, Bo Jönsson, Roger Berglund and Krister Wickman

helping to dramatically reduce energy consumption. It also reduces maintenance costs and contributes to enhanced safety and a better environment," added Jönsson.

"Products manufactured from Kanthal® APM and Kanthal APMT™ have been highly successful and we can see fantastic future business opportunities in demanding applications. Constantly developing innovative products and solutions is a prerequisite for our success," stated Björn Rosengren, President and CEO for Sandvik.

www.smt.sandvik.com

Bo Hu receives Höganäs' Ulf Engström Award 2017

Höganäs AB, Sweden, has announced that the 2017 Ulf Engström Award has been presented to Bo Hu, who works at the company's North American facility. Höganäs established the Ulf Engström Award in 2016 to encourage and recognise employee contributions to technical advancements and expanded commercial use of PM technology.

Bo Hu is said to have received the award for his contributions to both Höganäs and the PM industry. While at Höganäs, Hu has worked to develop a line of Super Machinability (SM) additives that help PM customers in the automobile and related industries to machine their products more efficiently and consistently.

Hu's work developing the company's SM3, SM4 and Stainless Steel EZ grades is said to have been highly successful. When SM3 was unveiled in 2010, it became one of the most successful new products launched by Höganäs in the past 20 years in terms of increased sales and added value for customers.

Roland Warzel, one of several colleagues who nominated Hu for the honour, wrote that the additive is only one part of Hu's successful formula. In his nomination letter, he stated, "Bo's knowledge on machining and how to optimise the machining process to maximise the additive benefit is a key differentiation which our competition cannot match."

"It is very important to work with the customer in an actual manufacturing environment. We do research and have the depth of understanding of the materials. But the machinist doesn't know the material and the material engineer doesn't know

Staffan Bohman, Bo Hu, Melker Jernberg and Dean Howard

machining. It's very complicated, and kind of a mystery. It's not just the materials, it's the tools and the conditions. We try to fill the gaps," stated Hu.

The jury cited Hu's ground breaking work and "continuous superior technical support", but also recognised his humility. "Bo generously shares his knowledge with his colleagues and listens to other people's views," the jury wrote. "Bo never looks for individual accolades, but insists on a team aspect of successes."

www.hoganas.com

Sintering 2017 Plenary speakers announced

The plenary speakers for the International Conference on Sintering (Sintering 2017), San Diego, California, USA, November 12-16, 2017, have been announced as Dr Didier Bouvard, Dr Martin Harmer and Professor Bernd Kieback. Organised by The American Ceramic Society, Sintering 2017 follows previous conferences that have taken place in the USA, France, Korea and Germany.

Dr Didier Bouvard lectures in mechanics, materials science and chemical engineering at the Université Grenoble Alpes in Grenoble, France. As plenary speaker, Bouvard will present his paper 'Investigating the sintering of multilayer components with advanced experimental and modelling tools'.

Dr Martin Harmer, Alcoa Foundation Professor of Material Science and Engineering and Senior Faculty Advisor for Research Initiatives at Lehigh University, Bethlehem, Pennsylvania, USA, will present his paper titled 'Know your boundaries', which looks at understanding the limitations of Powder Metallurgy processing.

Professor Bernd Kieback, of the Fraunhofer Society, Munich, Germany, will present the final plenary paper: 'Contact Formation and Densification during Early Stages of Spark Plasma Sintering of Metal Powders'.

The conference will address the latest developments in the sintering and microstructural evolution processes for the fabrication of powder-based materials in terms of fundamental understanding, technological issues and industrial applications.

www.ceramics.org

Linde to present its atmosphere control technology

Linde LLC's Metals Industry segment will detail atmosphere control technology that can address the challenge of total quality control and protect furnace equipment, in two presentations in the Furnace Atmosphere & Control technical session, at POWDERMET2017, Las Vegas, USA.

Akin Malas, Head of Applications Technology, Metals, Linde LLC, will present "Carbon Control: PM Industry Challenges and Practical Solutions in the Sintering Process." Grzegorz Moroz, Program Manager, Metals, Linde LLC, will present "Protection of Sintering Furnace Equipment Against Corrosion and Carburization."

Linde will also attend POWDERMET2017 as exhibitors, at booth #320.

www.linde-worldwide.com

MPIF announces 2017 Distinguished Service to PM Award recipients

The Metal Powder Industries Federation's (MPIF) Awards Committee has announced the recipients of the 2017 MPIF Distinguished Service to Powder Metallurgy (PM) Award. The award recognises individuals who have actively served the North American PM industry for at least 25 years and is judged by a panel of industry peers.

The 2017 award recipients are as follows:

- Eric Iver Anderson, FAPMI, Ames Laboratory
- Diran Apelian, FAPMI, Worcester Polytechnic Institute
- Sherri R. Bingert, Los Alamos National Laboratory (retired)
- Matthew Bulger, NetShape Technologies, Inc.
- Dean Howard, PMT, North American Höganäs, Inc.
- Mark D. Kesterholt, Rio Tinto Metal Powders (retired)
- Sydney H. Luk, Royal Metal Powders Inc.
- Glen Moore, Burgess-Norton Mfg. Co. (retired)
- Thomas J. Pontzer, Gasbarre Products, Inc. (retired)
- JoAnne Ryan, Alpha Sintered Metals, Inc.
- Rohith Shivanath, Stackpole International Canada
- John Sweet, FMS Corporation

All awards will be received at a special awards ceremony to take place at the PM Industry Luncheon, June 14, 2017, at the POWDERMET2017 conference, Las Vegas, Nevada, USA. Those wishing to attend the awards ceremony can find further information via the POWDERMET2017 website.

www.powdermet2017.org
www.mpif.org

TAT Technologies adds new dates for sintering courses

TAT Technologies has announced additional dates in August 2017 for its popular sintering courses which take place at the company's training centre in Pennsylvania, USA. The first course, "Preparation for Better Sintering," will run from August 22-25. The second course, "Sintering – Ferrous PM," runs from August 28-31.

Both courses include hands-on training and have common objectives. "We want class attendees to go back to their respective plants with some basic knowledge of furnaces, atmospheres and commercial sintering practices. It is our belief that this knowledge will give students the confidence to assist their plant's sintering operation," stated TAT.

www.tat-tech.com

Automotive teardown: Dismantling of three modern vehicles to discover current and potential uses for PM

In order to establish a better understanding of the use of Powder Metallurgy components in modern automobiles, a team of engineers from Höganäs AB recently stripped back three new vehicles to their component parts. As well as discovering the exact content of PM in each vehicle, the team were able to identify numerous components that could easily be converted to PM. Anders Flodin, Application Development Manager at Höganäs AB, reports on the findings of the project.

There are many components in an automobile that can be made using Powder Metallurgy technology. The majority of these are found in engine and transmission applications, with other parts including, for example, those found in oil pumps, shock absorbers, turbochargers, brake systems and many others. New material developments and processing techniques are continuing to open up new applications for PM in the growing automotive market.

However, despite the ability of PM to offer numerous advantages over other manufacturing technologies, not all parts that can be made by PM actually are. Also, the quantity and weight of PM parts found in automotive applications can vary greatly depending on geographical region. Current estimates for the weight of PM found in automobiles in various markets are shown in Fig. 1.

Recent car sales figures indicate that auto production is growing at a higher pace than the growth in the production of PM parts would indicate. This could be due to numerous reasons, including perhaps the disproportionate growth in automobile production in China, where historically the use of PM in vehicles is low. Also, the global downsizing of engines and the move towards electric drive systems to meet environmental concerns has impacted on the size, and therefore weight, of PM parts found in modern cars.

Of course the reasons for regional variations and the under utilisation of PM technology are complex, but clearly there is still potential for the growth of PM in the auto sector. To try

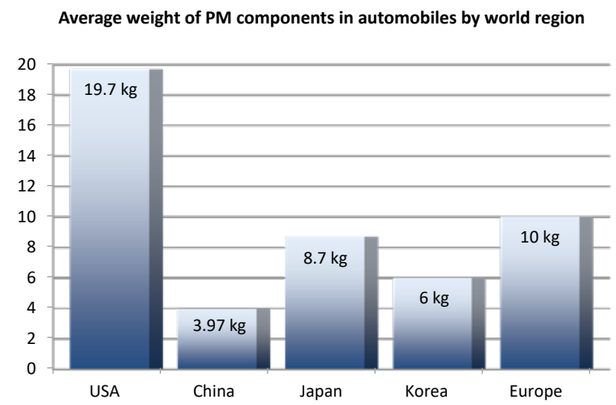

Fig. 1 The weight of PM found in automobiles in various regional markets [1-4]

Fig. 2 Höganäs chose the Toyota Yaris Hybrid, Volkswagen Passat GTE PHEV and Ford F150 as examples of popular modern automobiles in order to understand the current use of PM and identify further applications

and discover just how much potential there still is for PM in automotive applications, a team of engineers at Höganäs AB have been working on a project to identify the current usage of PM in a number of different vehicles. The aim is to teardown a selection of modern cars to their component parts and analyse the Powder Metallurgy content. As well as discovering the potential opportunities for converting parts to PM, the team could also highlight any design trends that could result in threats to existing PM applications.

Sample cars representing a cross section of modern automotive design

Höganäs AB purchased three sample cars for this particular project (Fig. 2) and, although three data point entries is a small sampling, the results could at least be seen as an indication as to where the PM content can be found in a modern car. Many different makes and models were considered during the selection process, with the final vehicles being chosen based on two main criteria.

Market: Three geographical regions were identified for the focus of the project; Asia, Europe and the US. These markets were chosen for their strategic importance to Höganäs AB's business, as well as for the ease of acquiring the cars.

Technology: The main criteria was to identify 'modern cars', incorporating the latest technology and reflecting a large segment of the market. The technology should be representative of cars that will be in production in the coming years, not those that have been in production for many years and are now being phased out. Höganäs wanted to look into the future and not the past.

Although no pure electric car was chosen, it was certainly debated internally. The reason for not choosing an electric vehicle at this stage was that the market share of electric cars is still very low. It is of course predicted to grow, but the rate at which it is growing is slow enough to allow for many technical changes to occur before an annual sales volume of even 20% is reached. It was therefore concluded that any findings from disassembling a pure electric car could be obsolete by the time the sales volumes reach interesting numbers, with the wrong conclusions being drawn if an immature vehicle technology was chosen.

Asia: Toyota Yaris Hybrid

The Toyota Yaris Hybrid, said to be the second best seller in Japan at the time, was the team's first purchase. Although in Japan it is actually sold without the hybridisation, this option is available in Europe and showcases Toyota's hybrid technology in a small family car. A 73 bhp 1.5 litre petrol engine and a 59 bhp electric motor combine via a CVT automatic gearbox.

The number one best seller in Japan at the time of purchase was the Toyota Prius model. However, this car was actually unavailable to buy in Sweden. Importing cars into Sweden is difficult and expensive, so if the car was to be rebuilt with PM parts as a demonstrator, making it street legal could pose problems.

Europe: Volkswagen Passat GTE PHEV

This Passat GTE PHEV is a new model from Volkswagen that allows up to 50 Km of driving in pure electric mode at highway speeds. The mid-sized family car is powered through a combination of a 154 bhp 1.4 TSI petrol engine and a 114 bhp electric motor, giving a total system output of 215bhp. The model represents a good example of hybrid technology for mass production from the world's largest automotive manufacturer.

USA: Ford F150

The US auto market is dominated by sales of pick-up trucks and SUV's. In 2016 the Ford F-Series was the bestselling vehicle in the US, with over 800,000 sales during the year (5). As a matter of fact, the top three positions in the sales league are all occupied by trucks (Ford F-Series, Chevy Silverado, RAM Trucks (5)). The Toyota Camry, at number four, is the top selling sedan in the list. So, with trucks representing a very common type of vehicle in the US and sharing components and systems with the SUVs, the Ford F-150 was chosen as the final vehicle for this project.

Fig. 3 The Toyota Yaris 1.5 Hybrid was one of the cars chosen to identify future applications for Powder Metallurgy components

Dismantling each vehicle to identify its component parts

The dismantling of both the Toyota Yaris and VW Passat were performed in Sweden, with the Ford F150 being taken apart in US as it was not practical to import this vehicle. A local car mechanic was used at both locations. The cars were broken back to their component parts, which in numerous cases resulted in the destruction of assemblies, such as shock absorbers, to gain access. Electrical motors and controls were also disassembled to look for possible soft magnetic applications. Components for brazing, surface coating and MIM were also identified.

Several hundred parts were documented for each vehicle. Entries included component dimensions, weights, materials and location in the vehicle. The team at Höganäs took many pictures and used Prezi software to help collate the data for each part. A searchable database was created using MS Access that allowed the searching of different sub systems such as weight intervals or materials etc. With so many components used in the manufacture of a vehicle, the teardown team assessed and documented only those parts that were felt relevant to the project. Those parts that were obviously of no interest to the PM industry, such as seat cushions, wind screens etc, were not documented.

The teardown process took on average ten working days, with a

Fig. 4 Cam system in Toyota Yaris Hybrid

Fig. 5 Powder Metallurgy chain sprocket (highlighted with the arrow). The sensor wheel underneath is stamped steel

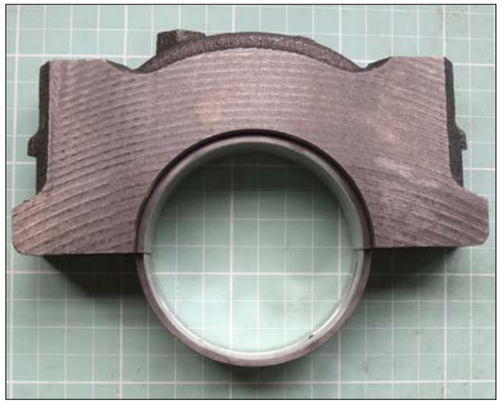

Fig. 6 Main bearing cap

team of three people that included two people documenting and one mechanic dismantling the car. The re-assembly (VW and Toyota), which was not documented, took around five working days with one to two mechanics.

Toyota Yaris 1.5 HSD five door Hybrid

The Toyota Yaris HSD Hybrid is equipped with a 1.5 litre gasoline engine (Fig. 3). The Yaris, just like the Prius, has a ground-breaking transmission system. Ground-breaking, that is, in that it does not have a clutch but two electric motors that can counter rotate a planetary gear system to achieve a geared neutral, despite the internal combustion engine (ICE) running without a clutch disengaging the crankshaft from the transmission.

Cam system

The ICE has double overhead cam shafts and a variable valve timing (VVT) system (Fig. 4). The VVT system is hydraulic on the intake cam and synchronised using a chain with the exhaust cam. This construction can be considered a standard solution and unlike more expensive Toyota models does not have the electric VVT system. The cam phaser is still made via PM, unlike on the electric VVT systems, but the exhaust cam sprocket is stamped steel. The bearing caps are aluminium. The PM parts were found to be the VVT rotor, housing, sprocket and a 10 g part in the chain tensioner.

The possible opportunities for Powder Metallurgy in the cam system would be in the form of sintered cam lobes, a technique that would result in an assembled cam shaft being produced. This well known technology is used in a number of cars, such as the Smart cars built by Daimler, and also in numerous trucks. Germany's EMAG GmbH & Co. KG is one supplier of this technology, but there are many others around the world. In the Yaris, the camshaft is cast and the lobes slide against the hydraulically tensioned buckets, a design that has been around for quite some time. Normally the contact stresses would be within reach of a nitrided PM cam lobe so this is definitely an opportunity.

The bearing caps in aluminium could also be made in sintered aluminium together with the bigger end cap shown in Fig. 4. The trend for light weighting vehicles will not be reversed and light weight PM will be sought after in the future. There is also new technology for cylinder heads, where the cam and cylinder head are assembled without any bearing end caps. This technology demands an assembled camshaft and is utilised by VW, for instance, this will be described later in this report.

Crank mechanism

In the crank mechanism the only PM part found in the Yaris was a 70 g chain sprocket driving the cam shafts (Fig. 5). The crank shaft itself has never been a major consideration for PM. It is, however, an interesting proposition that it could be made as an assembled crank shaft. Assembled crankshafts were used in the 1970s by SAAB, made from forged steel parts. It has not been made in PM, but a smaller crankshaft for a three-cylinder engine has been prototyped. Whether it would be cost competitive is another question of course, but it would result in a lot of PM parts and material. The crank shaft angle sensor wheel under the chain sprocket is made in stamped steel. Converting this back to a PM part is unlikely due to cost.

Fig. 7 This connecting rod is produced from forged steel

Main bearing cap

Shown in Fig. 6 is the main bearing end cap, currently made of steel. This could also have been made in PM and it is unclear in this application why this was not the case. It could be that the cost advantage is not the same in Japan, or maybe that the supplier base is not established and there is simply not a supplier that is close enough to the Yaris manufacturing line. It is often the case that Japanese automakers prefer to have a supplier base close by.

Connecting rods

The connecting rods in Fig. 7 are made in forged steel and not powder forged, so here is another opportunity for PM. The reasons for choosing forged steel rods could be that local sourcing is not available, or that the engine has very high combustion pressure due to a turbo or supercharger, but for the Yaris which has a relatively low compression naturally aspirated engine, powder forged connecting rods would likely be a viable option.

Other opportunities

In the valve train the only PM part was the valve seat inserts with a weight of 8 g per seat. The AC compressor (Fig. 8) already has many PM parts, with very few opportunities left. The transmission also contains quite a lot of parts that are PM friendly; sun, planet and ring gears for instance. There exists one particularly complex machined ring gear in the Yaris (Fig. 9), which includes an integrated parking gear and external and internal helical gear

Fig. 8 AC compressor. The scroll (bottom right) is made in aluminium

Fig. 9 Two piece designed helical ring gear, parking lock and external gearing

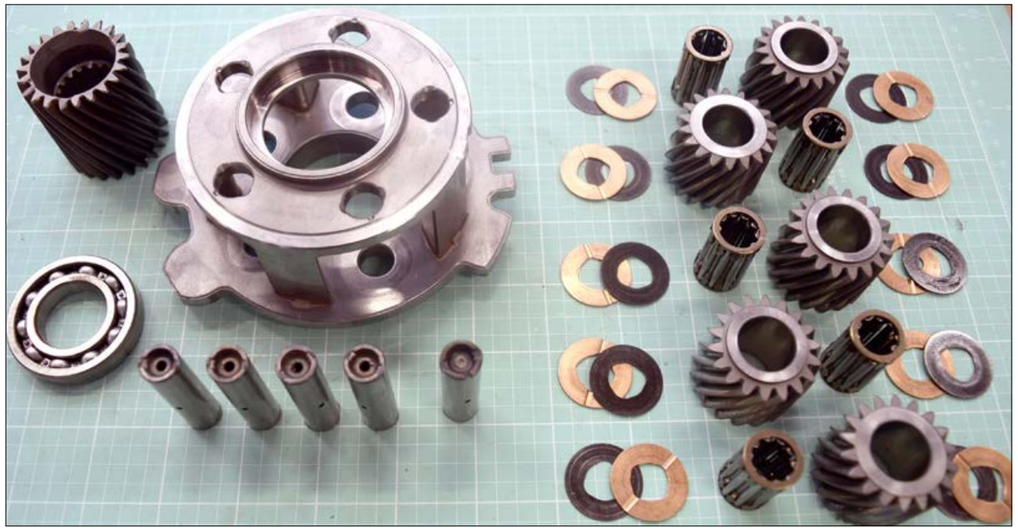

Fig. 10 One of the planetary assemblies

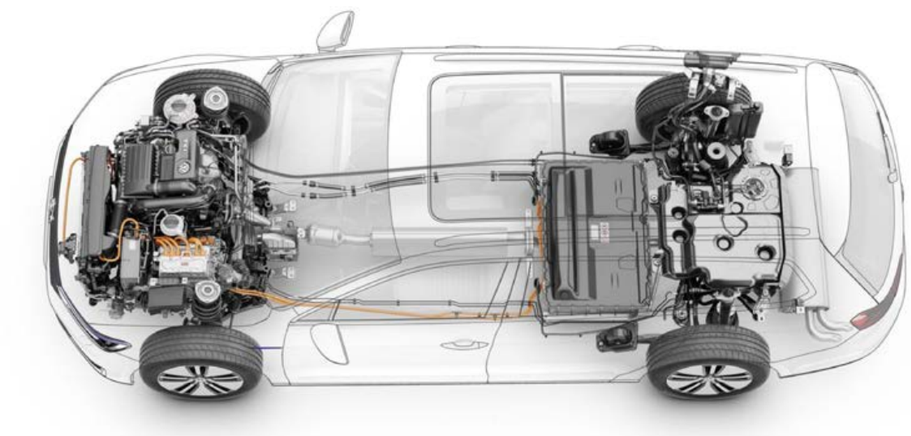

Fig. 11 VW Passat GTE showing location of hybrid system within the car

teeth. Here, PM could demonstrate its capabilities and make it as a near net-shape part, requiring much less machining. The part weighs over 2 kgs.

There are also pinions and planets in the transmission that easily could have been made in PM. However the benefit of PM being able to make these complex shapes is perhaps not as easily exploited in these applications. One of the carriers seen in Fig. 10 is made with PM, the other carrier is made from stamped steel. The differential gears would be a good candidate for PM forged gears, but in this transmission the differential gears are made of wrought steel, as well as the final drive. The parking pawl could be another candidate if forged. The amount of qualification that goes in to the parking gear and pawl often exceeds the work for qualifying a gear, however, because of the safety critical aspect of such a component. It may look an easy target, but there is often more to it than meets the eye.

A total of 3.2 kg of PM

In the Toyota Yaris a total of 3.2 kg of PM was found. Some typical PM components, such as sprockets, had been replaced by sheet steel. The general opportunities were gears, electric motors, cam lobes and connecting rods. Some smaller parts were found that could become a good conversion opportunity, but they are very specific to this particular car.

Fig. 12 1.4L TSI engine Electric motor and transmission

Volkswagen Passat GTE PHEV

Volkswagen couples its turbo-charged 1.4 TSI direct gasoline injection engine with a three-phase permanent magnet synchronous electric motor to power the Passat GTE (Fig. 11). The electric motor sits between the engine and the car's six speed dual-clutch transmission (DCT) system as shown in Fig. 12.

Hybrid system

The hybrid system adds complexity and numerous additional parts to the car. Electrification requires more water circuits, a control unit, DC/DC converter and motor. In total, four water pumps are used in this Passat for different systems, with one circuit also connected to air-conditioning to cool the battery due to the heat generated by charging and discharging. Many of the parts found in these systems could be candidates for future Soft Magnetic Composite (SMC) applications as well as the electric motor.

Pulleys and pumps

From a structural parts perspective, most applications are found in the engine and transmission. Different pulleys such as water pump and oil pump pulleys were found. The oil pump (Fig. 13) was a gear type pump using PM in the gears.

Fig. 13 Oil pump assembly

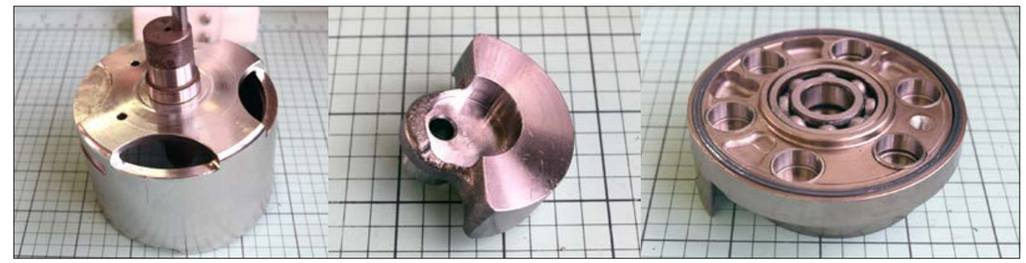

Fig. 14 Non PM parts in AC compressor

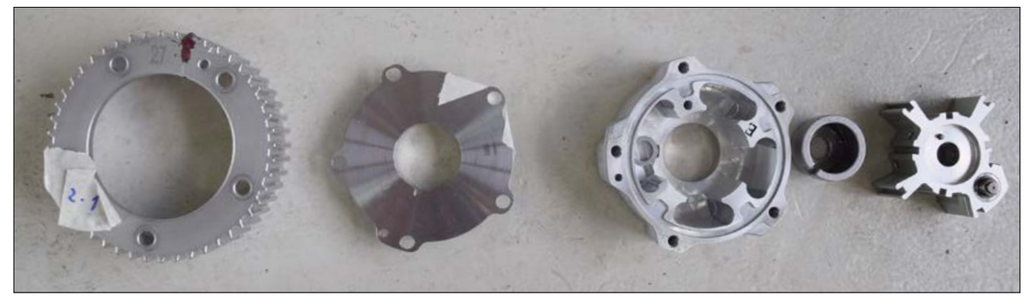

Fig. 15 VVT components

Cam system

The cylinder head had valve guides and valve seat inserts made from PM. The head has an integrated camshaft where the camshaft is assembled using loose cam lobes that are press fitted to the shaft. The followers are of roller type which is normally designed with high contact stresses putting special demands on the lobe. For this to be a PM lobe, special attention would have to be paid to make sure contact stresses can be met. Assembled cam shafts using PM lobes are of course already available and these can offer lower costs due to the reduced machining required in producing the lobes.

AC compressor

The air conditioning compressor in the Passat is electrically driven so that the system can operate even when in full electric driving mode. With this configuration it could also be possible to cool batteries during rapid charging, but it is unclear if that is an option for the Passat. However, this may be a solution for newer platforms featuring any form of electric-drive.

There are many possible PM parts in the AC compressor but only one is made of PM in the Passat (Fig. 14). Compare this to the Yaris that had many more PM parts.

VVT system

The VVT system in the Passat (Fig. 15) is belt driven. However, electrically driven and controlled VVT systems have been on the market for many years. The trend is towards electrical systems due to faster control which improves emissions.

In the VVT mechanism, only the drive sprocket (far left part in Fig. 15) is made in PM. The housing and rotor are made in aluminium, while the plungers are made in regular steel. The reason for choosing aluminium is likely to be to reduce weight and inertia in the rotor for a faster response.

Fig. 16 Electrical parking brake actuator

Fig. 17 Parking gear in the Passat dual-clutch transmission (DCT) system

Other opportunities

In the electrical parking brake system depicted in Fig. 16, only one 10 g PM component was found, a small arm (top row, second from left in Fig. 16), but the gears are plastic or brass and the shaft holder (second row, second from left) is aluminium.

In the transmission, the synchroniser hubs were found to be PM but none of the gears.

One interesting component is the parking gear (Fig. 17). The parking gear is a heavily machined component and could be made in PM, either as powder forged or maybe sinter hardened. The parking gear is a safety critical component and is made using powder forging in many cars with automatic transmission. It is one of the most computer simulated and tested parts due to its function to hold the car still at all times when parked.

The differential cage and gears could be another possible PM component. With some redesign the cage could be compactable. The gears are already made using powder forging and in use in many cars and trucks. The cage would make a nice addition to the total amount of PM in this car. It is also a component that is found in every car, including almost all electrically powered vehicles.

Also, here the transmission gears would be a good component for conversion to PM. Transmissions are found in almost every car, including the electric cars, even though up to now they are mostly designed as fixed two-stage transmissions. However this is likely to change for many reasons; some of them are technical, some marketing related. In the Passat there are more than 10 kg of gears that could be converted to PM, a good opportunity for the industry.

The electric motors are also an opportunity for SMC material. Not every motor is suitable, but the pancake stack design used in many P1, P2, P3 and P4 hybrids lends itself to PM design and the weight is perhaps 7-10 kg in each car.

A total of 4.2 kg of PM

The team at Höganäs found the total amount of PM components in this Passat to be 4.2 kg. Unfortunately, some of the typical PM components had been converted to other technologies. This was evident, for example, in the variable valve timing (VVT) system, where the rotor and case has been made with competing technology; extrusion and machining of aluminium.

Ford F150

The F150, chosen for this project by Höganäs, has a new ten-speed automatic transmission that is co-developed with GM and will be shared with a number of Ford and GM vehicles (Fig. 18). There is also a nine speed derivative for front wheel drive architecture. This model of the popular truck is also known for a number of weight saving features, with aluminium body panels attached to a steel frame.

It can of course be argued that this truck is not entirely representative of the average automobile seen in the USA, but it is of interest since the vehicle type is so dominant and shares the four-wheel drive architecture with many SUVs, requiring transfer case, shaft disconnects and one more differential, for example.

At the time of writing the dismantling of the Ford F150 is not fully documented and will not therefore be covered in detail here. However the findings so far correlate well with figures published by the MPIF for this type of vehicle, stating that these models typically contain over 27 kg of PM parts (6) - a striking contrast to what is found in modern vehicles such as the Passat and Yaris. This of course also raises questions on how dependent the US PM industry is on the country's demand for these trucks.

If the 20 best selling cars and trucks in the US (5) are analysed, it is found that the distribution between trucks, compact/mid size/large class cars and SUV/cross-over is quite evenly distributed, about a third for each segment in number of cars sold. Since we estimate that a truck has around 25 kg of PM parts (assuming not every truck has 4 wheel drive and extra differentials like the Ford F150) and if we assume that the SUVs and cross-overs have around 20 kg of powder in them, it is possible to estimate that the compact/mid size/large class vehicles should contain around 15 kg per car assuming the given average of 19.7 is correct (1). Based on these PM weights per typical car in each segment (25 kg, 20 kg, 15 kg), the PM value per segment is presented in pie chart in Fig. 19. From this it can be seen that trucks are the most important sector with 39% PM share by weight of PM part, followed by SUV/cross-over at 33% and compact/mid size/large class cars at 28%. Interestingly, some 72% of PM goes into trucks and SUVs.

It will of course be interesting to see how much PM there will be in a hybrid truck. Such variants are reported to be on the drawing board and Tesla has announced that it will also show an electric truck towards the end of 2017 as well as other types of commercial haulage vehicles. Meeting ever more strict emissions regulations will also require traditional truck and SUV manufacturers to head down this path, so the PM industry has to start developing new technology and applications that will keep up with these changes. Doing this will also increase the amount of PM in European and Asian cars, thereby growing the industry.

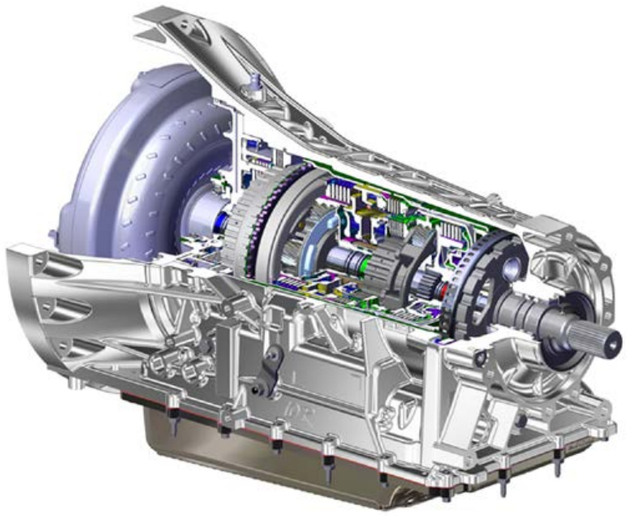

Fig. 18 The all-new ten-speed transmission in the F150 delivers improved acceleration and performance compared with previous versions

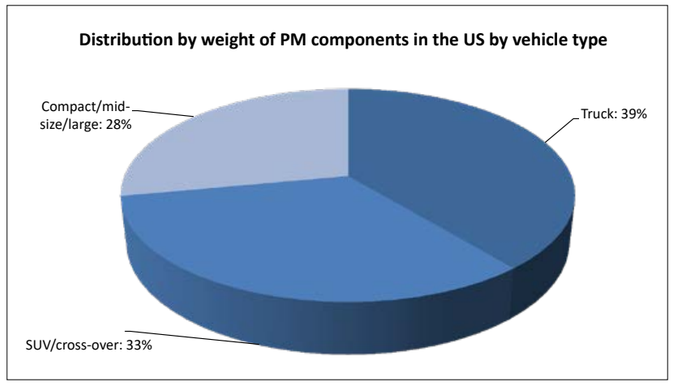

Fig. 19 Distribution of total tonnage between segments

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Lower volume applications for Powder Metallurgy at ASCO: Opportunities, challenges and best practices

ASCO Sintering, based in Commerce, California, USA, is an employee owned contract manufacturer of Powder Metallurgy components. The company has taken a novel approach to addressing a common situation found in manufacturing; namely how to address lower volume application opportunities in the marketplace. In this exclusive report, Larry Totzke discovers how the company has succeeded in the low volume segment of the market.

ASCO Sintering began its Powder Metallurgy operations back in 1964 and today is a leading manufacturer of a wide range of PM products. With a rich history and loyal workforce, the company possesses many years of engineering experience in PM design and manufacture. ASCO has, over time, developed innovative and proprietary tooling designs offering ever more shape complexity during the compaction process. Its powder compacting presses range from 4 to 220 tons and the company lists continuous belt and pusher sintering furnaces in its inventory. Fully implemented acoustic and electromagnetic resonance non-destructive testing lines allow the detection of internal manufacturing flaws.

Powder Metallurgy manufacturing technology is usually described as being suitable only for medium to high and even extremely high production quantities. Due to the processing variables involved, it can often be an engineering intense task to bring new Powder Metallurgy parts into production. In addition to supplying its customers with the typical high volume PM components, ASCO Sintering has cornered the market in providing short run quantities.

The automotive sector is the single largest market for PM in North America and it supports the production of very high quantities of components. It is recognised that there are over 19 kg (40 lbs) of PM parts in every North American car.

Fig. 1 ASCO Sintering, based in Commerce, California, USA, is an employee owned contract manufacturer of Powder Metallurgy components

Fig. 2 The series of 316 stainless steel bobbins are used in a braking system for race cars and high-performance vehicles. The two-level part is available in 14 variations with eight or more bobbins used in a single brake rotor assembly

They range from severe service in brakes and drive trains to applications for magnetics, fuel management, pollution control and safety. In 2016, over 17 million vehicles were sold in the USA, with over 12 million vehicles being manufactured in the country. Since a single PM part can be used across multiple platforms, it is not unusual for part runs in this industry to be in the millions of pieces.

Powder Metallurgy and its companion technologies such as casting, forming and machining, are the backbone of metal parts manufacturing. PM, with its inherent net-shape capability, can offer more flexibility and lower costs when compared to these other approaches. Accordingly, supported by advances in powder technology, new applications are being developed and the PM content in automotive continues to grow each year.

However, there are a number of situations, even in the automotive sector, where a low volume of parts is required. Often, this would be considered uneconomical to produce by Powder Metallurgy.

Powder Metallurgy can provide a viable manufacturing option

There are many metal parts designed, manufactured and assembled, where PM represents a viable manufacturing option. There are markets where a component type may be required in hundreds of millions per year, but where individual variants of the component may only be needed in volumes of a few thousand pieces. Whether it is a new product launch or legacy parts in decline, PM should be able to service these markets as well.

Trying to work within existing resources, management is always searching for ways to help their operations increase revenue. When applied selectively, the concept of short run production economics may help companies do just that. Manufacturing efficiencies increase proportionally with higher quantities. The challenge is how to apply the principles of high volume manufacturing to the area of lower part volume short runs.

For ASCO, in a single press campaign, short run can be anywhere from a few hundred to a few thousand. A small, single cavity mechanical press can manufacture 1500 parts per hour. Every part produced requires a dedicated set of compacting tooling which must be set into the press. Adding secondary operations, such as re-strike tooling or machining, will require additional dedicated tooling and therefore additional set-up time. Manufacturing run time can form a smaller percentage of the manufacturing cost as performing tool setup and change out can take longer than making the parts themselves. The challenge is increased when one considers that set-up time for manufacturing is a very precious commodity. In the final analysis, once we agree that the issue is economics, the final quantities produced become almost irrelevant.

Offering a short run option to customers

As one might expect, accepting short run manufacturing into the factory can be seen either as an opportunity or as a disruption. While all areas of the company need to be focused on meeting the customer's requirements, how short run is viewed varies considerably by company responsibility.

From the management desk

A company cannot lose sight of the ultimate objective of making a profit. Profits make it possible to pay employees, buy new equipment and continue to serve customers. By inserting short run production into the factory without expanding operations or requiring new equipment, factory utilisation can be increased. The accounting principle of absorption needs to be carefully evaluated. Typically, increased allocation of overhead across a larger base makes all products more profitable. While there are other options for making low volumes in PM (machining parts from PM billets, for example), in theory, if priced correctly and fairly, it is possible to justify the production of quantities down to a few dozen.

From the marketing and sales perspective

Low volume parts manufacturing represents an avenue for relationship building. This can be seen as a market penetration strategy to expand the customer base. When an RFQ is received, it represents a doorway into the company and can be viewed not just as a request to supply a proposal for price and delivery but as a request for support and dialogue. This dialogue gives the opportunity to demonstrate ASCO's problem solving capabilities on one side and then to learn how the customer does business on the other.

If the strategy of building a relationship with the customer is prioritised, then the RFQ/quotation cycle can be looked upon as a continuum. Winning or losing a discrete opportunity becomes less important as the objective, which is to get to know the customer and the company's policies and procedures. ASCO is nationally recognised as a PM manufacturing expert. By extending support and working in collaboration, the company is able to position itself as an extension of the customer's engineering department. Effectively, ASCO is able to get inside the customer's tent.

Fig. 3 Clutch rotor assembly consisting of four parts – an armature, rotor blank, bearing and pinion gear. The assembly operates in a motor drive for automatic sliding minivan doors and opening and closing tailgates. The parts are made to a net shape, except for the rotor which requires a turning operation on the hub. Innovative tooling provides the required part density to satisfy magnetic and strength properties of the rotor

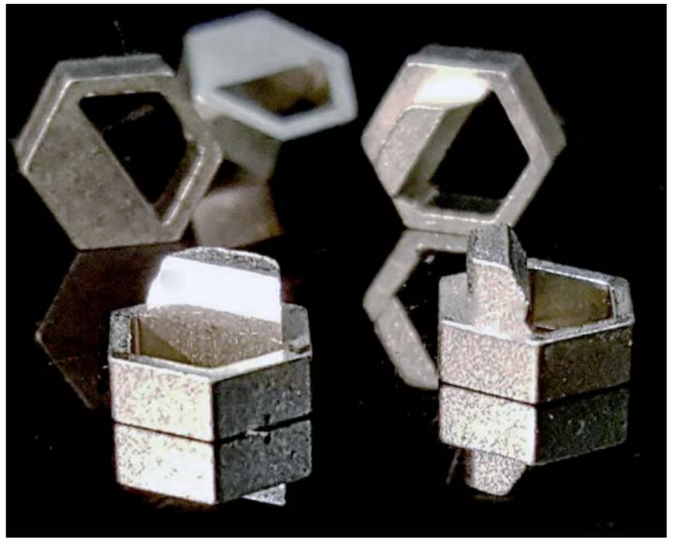

Fig. 4 These black-box polarising keys are used in electrical rack and panel connectors on aircraft flight data recorders. Close control of the sintering process is required to control ductility, distortion and eliminate the need for sizing. The parts must withstand a 500 connect/disconnect cycle test without measurable wear and are also tested for electrical conductivity. The net shape part requires no secondary operations and demonstrates a high degree of reliability. The keys can be found in almost every flight data recorder in commercial and military aircraft produced in the US

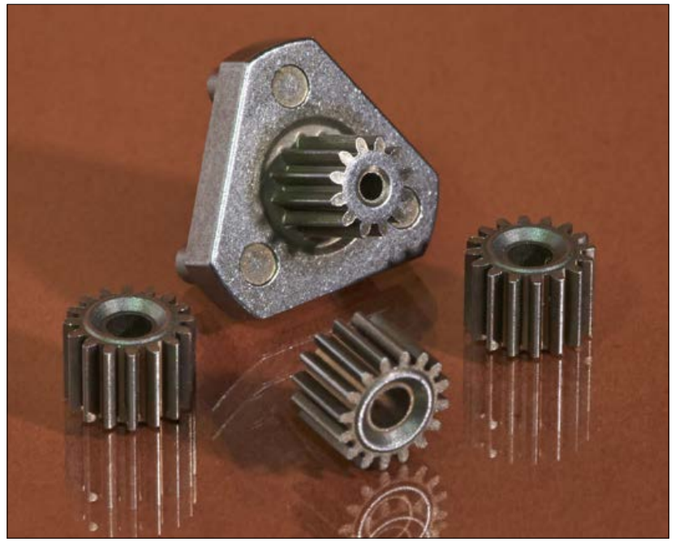

Fig. 5 A sinter-hardened steel planetary gear system, featuring a carrier with an integrated sun gear and three planetary gears. The system is used in multiple stacks for gear reduction in a single-use, portable, physician-operated surgical device. In addition to the integrated pinion gear, the carrier includes three posts that extend above the flange with a 2 to 1 length-to-diameter ratio. Proprietary press mechanisms were required to achieve the post density, as well as a proper post-to-flange bond. The carrier is pressed, sintered and tempered to net shape. By integrating the posts to the flange through advanced PM manufacturing techniques and by the elimination of a secondary heat-treating operation through the use of modern sinter-hardening materials, the new part design achieved a 60% cost reduction

Fig. 6 This idler pulley is made for a major snow blower manufacturer. The component is made from a machineable grade of FC-0208-50. The splines and precision bores are all pressed in net shape with only the pulley grooves being machined. Bearings are press fitted into the bores and these parts see constant engagement / disengagement during operation. Part strength and freedom from manufacturing defects are all important

From the quality assurance desk
Quantity is not a factor. ASCO uses a network linked SPC system so data collection is automatic. Sampling plans are established to achieve Cpk values. These Cpk values can be customer imposed or integrated from ASCO's standards. Increasing efficiency by eliminating waste and applying the principles of six sigma supports lower volume manufacturing. ASCO invests in lean manufacturing by certifying more than half of its employees as six sigma green belts positioned at all levels of the company. The efficiencies provided by the lean manufacturing practices to make low volume parts are an added benefit for higher volume manufacturing

From engineering
Custom tool designs are produced one at a time. However, advances in CAD have streamlined the process. From the design and process engineering desk there is the old adage that the time taken to develop tooling and processing is the same to make one piece as it is for a 100,000. Of course for a large majority of companies this is true, however, at ASCO there is only one system. This system is standardised and yet is able to satisfy high volume and short runs equally.

Factors to consider in short run applications

Unfortunately, PM manufacturing technology is often poorly understood by many of today's material and process engineers. Whatever quantity of parts is required, there are a number of factors that need to be considered.

Part/tool design
It is important that parts or components are designed for PM as close to first concept as possible. Correspondingly, this requires that an experienced parts manufacturer be involved early in the process as well. Engineering support from the parts producer in the form of material

Fig. 7 Automation is successfully integrated at ASCO with robotic systems helping to reduce the number of employees required to maintain 24 hour operation at the manufacturing facility

selection and part design is essential. This support will yield a sound part design. Sound part design will, in turn, provide durable tool design. During the pressing of the part, the tool design must support compaction pressures sometimes in excess of 50 tons/in^2 (689.5 MPa).

Material selection
Powder blends, the starting form of raw materials, are highly engineered and have a unique set of properties. As a generalisation, PM materials have higher carbon levels than cast or forged alternatives. Inherent in the PM process is residual porosity. Higher carbon values and residual porosity can lead to reduced dynamic mechanical properties (impact toughness and elongation). Selecting a common material will allow for a standardised powder blend.

Prototypes
Rarely does a PM parts producer build a set of compacting tools to prove out a concept. The opportunity cost is simply too great. When prototypes are required in PM, the most common approach is to machine from a billet or hockey puck shaped blank produced with a common thickness. Other options for prototypes include Additive Manufacturing or carbon moulds for castings. All of these are a viable way to proceed if the prototype design is predicated on sound PM manufacturing guidelines. If PM is selected from first concept then, once a final design is proven, transitioning into production is greatly simplified. The aspect of repeated qualification testing is also potentially eliminated.

Application engineering support
Understanding the given operating environment of a part is mandatory. Building on this approach allows for a process to be developed that assures that a part's performance criteria will be met.

The PM process can be tailored to provide optimum performance at the lowest cost. Variables to be controlled include density of the part, chemistry and sintering (times, temperatures and atmospheres). However, this approach cannot be taken when short runs are involved. Unless engineering resources are built into the original scope of work, short run is not compatible with trials directed at successive approximations. Once sintering is completed, a variety of secondary operations can be added. For example, the part can be sized for increased weight and/or dimensional control. It can also be welded, heat treated, machined or coated.

Automation: This applies both to low value and high value processes

When it comes to automating low-value processes, most of us think about robots doing repetitive tasks. Even using robots there is only so much efficiency that can be gained from streamlining shop floor work. In fact, most manufacturers already do this to some degree. As an indication of how well automation is integrated at ASCO, only 20 shop floor employees are now required to staff a 24 hour operation at its 6500 m^2 (70,000 ft^2) facility.

Engineering level tasks

ASCO has advanced the automation concept to include engineering level activities such as the quotation process. For example, taking the volume of the part allows the company to very accurately calculate the weight. With the weight, based upon the specific customer selection of materials, the company can define the raw material cost element of a part very quickly. Weight also drives related cost elements such as the sintering cycle and deburring times. The process starts when a 3D solid model or CAD file is uploaded to ASCO's website. It is essential to have a design that can actually be made, so the company's designers take the submitted design and, based on the fundamentals of PM manufacturing, modify the file and return it to the client. Once mutual agreement on the part design has been reached, standard charges by cost centre can be applied and pricing is generated. Most RFQ's can be turned around with credible proposals in the same day. With a credible proposal, ASCO is able to supply a total cost, based upon a clearly defined process for a fixed quantity. This streamlines the process by quickly allowing the end user to ascertain if low volume in PM is a viable option. Supplying the foundation of a clearly defined process makes it very easy for both the customer and ASCO to dial in cost model derivatives of adding in or taking out additional operations. The customer participates in the final manufacturing solution which should result in best part performance at the lowest possible cost.

Standardisation

In order to not only survive short run manufacturing but to prosper, the key is to compress the high cost engineering resources required, regardless of quantity or size, down to fewer hours. This can be accomplished by standardisation of both work instructions and hardware. It is a given that ASCO cannot standardise the parts. As a contract manufacturer it has no proprietary product lines to rely upon. As a result, ASCO has to refine its capabilities to match the particular requirements of its customers.

All PM companies standardise hard elements of tooling such as sintering equipment and press and tool hardware, such as clamp rings, adaptors, etc. ASCO also works to standardise processes such as utilising common powder blends, standardising sinter cycles (atmospheres and temperatures) and deburring media.

How has this strategy benefited ASCO Sintering?

On speaking with Neil Moore, President and CEO of ASCO, it is clear he is very enthusiastic about the company and its success in supplying short run volumes of PM parts. Regarding the streamlining of processes and standardisation methodology, Moore stated that this has been effectively integrated into the company, with the quote review process being well received in the market place. "What we have done is to try to understand the buyer – both their needs and mentality. Keep in mind that this is not roulette. The final pricing model still includes labour, material, set-up times, machine time plus an allocation for overheads."

There are, of course, a number of caveats to low volume manufacturing, one of which needs to be openly recognised - the issue of catastrophic tool failure. As previously stated, tool loads at compaction are extremely high. A set of compaction tooling can cost many thousands of dollars and whilst rare, whether due to press malfunction or material defect, tooling can break. Unfortunately this is most likely to occur during tool set-up. Sometimes, a small adjustment in powder fill into the die can result in an exponential increase in tool loads. "There simply is not sufficient revenue in the job for ASCO to assume total responsibility for the tool replacement cost. The customer is always notified that should this tool fail during normal operation that the replacement cost is the responsibility of the customer."

Moore went on to add, "In the cases where projects are not immediately possible to manufacture, engineering resources are also budgeted to provide the extended engineering support required. Low volume manufacturing pricing is not set at a premium here at ASCO, we strive to charge a fair price taking value into consideration. The objective is to be more active in the market place and, at the same time, we can demonstrate the capabilities of the company."

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Larry Totzke is now retired, living and consulting from his home in Southern California. Larry shares 44 years of metal parts manufacturing experience including castings, forgings, extrusions, MIM and Powder Metallurgy technologies. He was both a member of the Technical Program Committee and a Technical Session Chairman at PowderMet 2014, organised by the MPIF in Orlando, Florida.

Understanding the stages to successful delubrication of Powder Metallurgy components

The Gasbarre Furnace Group, a division of Gasbarre Products, offers a comprehensive spectrum of industrial heat treating equipment, engineering, technology and commercial-based solutions through its three companies, Sinterite, C.I. Hayes and J. L. Becker. In this article, Sinterite's Steven Smith discusses the important process of delubrication in the sintering of Powder Metallurgy components.

With products ranging from batch furnaces to continuous belt furnaces, pusher furnaces, vacuum furnaces, humpback furnaces and much more, the Gasbarre Furnace Group has an extensive knowledge and deep understanding of the sintering process. Through many years' experience of supplying sintering furnaces to the Powder Metallurgy industry, the group is ideally positioned to solve any application challenge. Successful removal of lubricants, prior to the final sintering of a PM part, can be one such challenge and the following article hopes to expand on some of the key issues to consider during this important step.

The use of lubricants in the Powder Metallurgy process is commonplace, being vital in terms of protecting components and tooling during the forming and ejection processes. During the sintering process these lubricants are thermally removed. However, this operation can lead to a number of issues with the final component if not undertaken correctly. Understanding the fundamental chemical forces at play during delubrication can provide process engineers with the proper insight to hone their production process. A well designed delubrication step will result in higher quality parts and lower equipment maintenance costs.

A recognised industry-leading lubricant is Lonza's Acrawax®, an ethylene bis-stear amide (or EBS) represented by the chemical formula $C_{38}H_{76}N_2O_2$. Acrawax melts

Fig. 1 A well designed delubrication step will result in higher quality parts and lower equipment maintenance costs

$C_{38}H_{76}N_2O_2$	592 g/mole	
Available Carbon		
Parts	350 lbs	
Lube %	0.75%	
Lube Wt	2.625 lbs	*Lbs x Lube %*
	1.19 kg	*Lbs/(2.2lbs/kg)*
	1.193 g	*kg*100*
	2.02 moles	*g lube / (EBS g/mole)*
	76.59 moles	*38 C atoms/molecule EBS*
Lube	919.07 g	*moles C x 12 g/mole*
Carbon	2.02 lbs	*g x (2.2 lbs/1000g)*
Oxidiser required		
Water	1,379 g	*moles C x g/mole*
	3.03 lbs	*g x (2.2 lbs/1000g)*
Water required	**0.38 gallons**	
Carbon	76.59 moles	*38 C atoms/molecule EBS*
Oxygen	21.0% % of Air	*Air Composition*
Air required	731.16 moles	*(2 x moles C) / O% Air*
Air	21,182 g	*g/mole of air x moles of air*
	46.60 lbs	*g x (2.2 lbs/1000g)*
Air required	**585 ft³**	

	g/mole
Carbon	12
Water	18
Oxygen	16
Hydrogen	1
Air	28.97
O_2	32

A mole is the amount of pure substance containing the same number of chemical units as there are atoms in exactly 12 grams of carbon -12 (i.e. 6.023 X 1023)

Table 1 Water or air required to form CO_2 from available carbon

at 144°C (291°F) and vaporises at 260°C (500°F). In the 510-565°C (950-1050°F) temperature range the methane (CH_4), carbon monoxide (CO) and C_xH_{x+2} molecules decompose to soot via these reversible reactions:

- 2CO <-> 2C (soot) + 0_2
- CH_4 <-> C (soot) + 2 H_2
- C_xH_{x+2} <-> xC (soot) + (x+2) H_2

This decomposition to soot is accelerated by the presence of elemental nickel, zinc oxide (ZnO) from zinc stearate and high surface area iron powder. This is the primary source of unwanted carbon in a sintering furnace. This carbon is carried by the belt through the high heat section into the cooling section, causing a variety of problems - which will be discussed later in this article.

Decomposition to soot

When the decomposition to soot occurs outside the part, black soot is deposited on the parts and in the furnace. Soot that forms inside the part inhibits atomic motion over the iron particle surfaces and prevents the development of necks or bonds between the particles. Soot build-up can even rupture the surface of the part. To prevent this blistering, all of the high carbon potential gas molecules should be removed from the part before they can decompose into soot. This can be accomplished by oxidising the carbon atoms to CO_2 and water vapour - noting that this has to occur below 510°C (950°F).

Inspection of the EBS molecular formula $C_{38}H_{76}N_2O_2$ clearly shows there is not enough oxygen to oxidise all of the carbon. For a one-kilogram part with 0.75% EBS we would need 1.5 wt.% oxygen. Oxidation can be accomplished by injecting water vapour, CO_2, or air directly into the delube zone. Blistering is more prevalent in higher density compacts and parts containing nickel.

Calculating oxidation requirements

Table 1 demonstrates how to determine the minimum amount of oxidiser needed to combine with the present carbon to form CO_2, again keeping in mind that this reaction needs to occur below 510°C (950°F). In this example we shall be looking at 158 kg (350 lbs) of compacted powder metal parts that were pressed with 0.75% by weight Acrawax® lubricant. This means that the parts would have

TEST REPORT

Sinterite P.O. No: 72376
310 State Road Date Received: 1/9/12
St. Marys, PA Date Tested: 1/9-12/12

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PAS Lab No: 1464 Report Date: 1/12/11

Element	Sample	314 SS Spec
C	0.06	.25 Max
Mn	1.3	2.0 Max
P	0.027	.045 Max
S	0.01	.030 Max
Si	1.0	1.5 Max
Cu	0.29	.35 Max
Ni	20	19.0/22.0 Max
Cr	14.8	23.0/26.0 Max
Mo	0.15	
Al	<0.1	

Table 2 Material sample analysis of slugs

1.19 kg (2.625 lbs) of lube present which would need to be removed prior to sintering. The parts contain 1,193 g of lubricant, which has 592 g per mole of EBS. We need to combine 2.02 moles carbon with enough oxygen in order to form the necessary CO_2, avoiding sooting.

Since there are 38 carbon atoms in every molecule of EBS, this particular example has 76.59 moles of carbon requiring 153.18 moles of oxygen to form the CO_2. Water, having two oxygen atoms per molecule, would require the same number of moles as the carbon that is available. In this example 1.73 litres (0.38 gallons) of water is the minimum amount. If air is the oxidiser, the percentage of oxygen in the air and the need for two oxygen atoms per carbon atom must be taken into account. With the details shown, the minimum amount of air required would be 16.57 m³ (585 ft³). This type of calculation is required to determine the air or water flow rate settings for the preheat delubrication section of the furnace. If insufficient oxidiser is provided, soot will form as the lubricant moves into the higher temperature sections of the furnace.

Fig. 2 Belt melting

Consequences of improper delubrication

Now we will review several of the many adverse consequences of sooting caused by improper delubrication. Possibly the most significant impact is on the physical property performance of the sintered part. Soot remaining in the part will interfere with neck development between the particles, which may result in inferior strength properties. The soot can also alter the chemistry of the alloy, affecting both static and dynamic part properties - particularly troublesome in highly engineered, high-performance parts. Soot will also cause problems with the furnace, especially the belt, muffle, and accelerated cooling units. Carbon soot in a stainless steel wire mesh belt furnace will result in premature failure of the belt, as shown in Fig. 2.

Material slugs

Material slugs similar to those shown in Fig. 2 are commonly found in sintering furnaces, occasionally being pulled out of the furnace and deposited around the unload table. In order to determine how they are formed, a first step is to perform a chemical analysis to determine their composition.

Table 2 is taken from a study of a sintering furnace using a 314 stainless steel wire mesh belt. Shown is the material sample analysis of the slugs. Carbon, manganese, phosphorus, sulphur, silicon, copper, nickel, chromium, molybdenum and aluminium were measured and compared to the

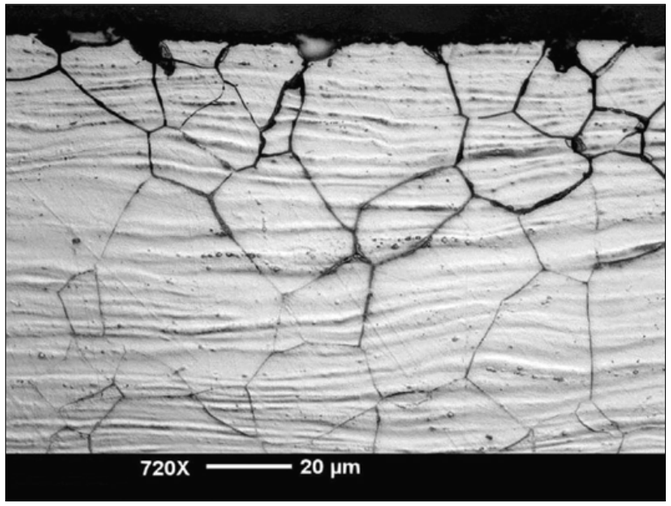

Fig. 3 Inter-granular corrosion attack in austenitic cold rolled stainless steel sheet

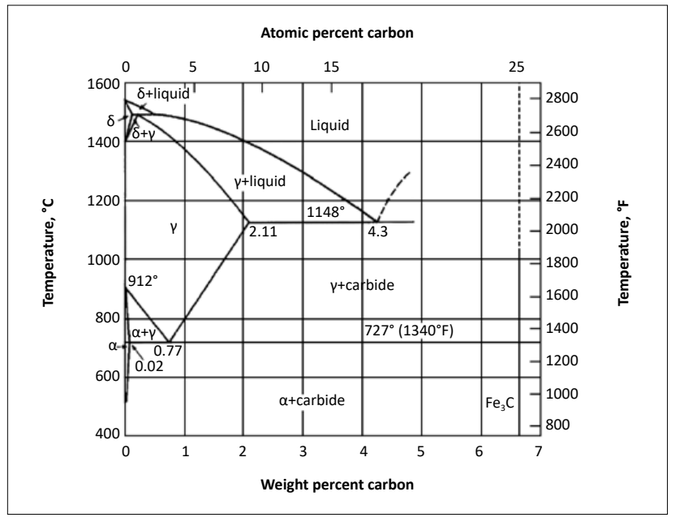

Fig. 4 Iron-carbon (Fe-C) binary phase diagram, showing at temps > 1150°C (2100°F), iron and carbon react to form a low melting liquid

formulation of 314SS. All tested elements were within range of the 314SS specification with the exception of chromium, which was nearly half of what is required. Given that the source material for the belt had tested within specification, it was concluded that the chromium had been depleted from the belt material during processing in the furnace.

The current best theory that explains the formation of the slugs is that available carbon in the high heat model forms chromium carbides in the grain boundaries of the stainless steel belt. This carbide formation consumes chromium, reducing its content in the samples. Additionally, the chrome carbides cause intergranular corrosion of the crystallites of stainless steel, making available free crystallites. Then, the available carbon in the muffle enables eutectic melting of the stainless steel crystallites which cumulatively forms the slugs. Therefore the root cause of the problem is available carbon in the high heat section due to the inadequate delubrication of the PM part in the preheat section of the furnace.

Intergranular corrosion

An example of intergranular corrosion in a stainless steel is shown in Fig. 3. The missing spaces at the top of the sample are the missing crystallites that collect on the muffle floor, encounter carbon soot, melt eutectically and add to the build-up of the slugs. As the intergranular corrosion and loss of material progresses, the belt weakens - shortening its service life.

Iron comprises the bulk of a 314SS alloy and eutectic melting can occur, even at the molecular level. Fig. 4 is the iron-carbon binary phase diagram showing that at temperatures around 1150°C (2100°F) iron and carbon can react to form a low melting point liquid. The normal operating temperature of the high heat section of a sintering furnace is above 1093°C (2000°F), enabling melting with the right amount of available carbon. Later discussion will show a similar response of carbon with nickel, particularly in the presence of silicon.

Chemistry of carbon soot

Next we will explore the chemistry of carbon soot in the high heat section of a sintering furnace that uses a silicon carbide ceramic muffle. Carbon that is carried into the high heat section of a sintering furnace mixes with silicon carbide that has been worn from the muffle surface by the sliding of the belt. Hydrogen, in certain conditions, can combine with the carbon in the silicon carbide molecule, forming methane which flows out of the furnace - leaving free silicon. The availability of carbon and silicon causes another mechanism for eutectic melting that shortens belt service life. The silicon nickel phase diagram shown in Fig. 5 exhibits the temperature and resulting phase as a function of mole fraction of silicon and nickel. The red outline section of the phase diagram is shown expanded to the right. Liquid phase can be achieved in the 1150-1200°C (2100 to 2200°F) temperature range for a band of mole fraction ratios. With the introduction of carbon to the nickel silicon system (Fig. 6), the phase diagram shows that eutectic melting can occur below 1150°C (2100°F). This eutectic melting is the mechanism that forms the slugs shown earlier in Fig. 2.

Accelerated cooling

Many modern sintering furnaces are equipped with some form of an accelerated cooling unit used to achieve sinter hardening of the parts as they leave the high heat section of the furnace. Common to all accelerated cooling units is the use of an atmosphere to water heat exchanger that cools the atmosphere after it has pulled heat from the parts. Since these units rely on high velocity atmosphere flow and recirculation, if carbon is present in the cooling chamber it will be pulled through the heat exchanger, resulting in a buildup of carbon on the heat exchanger fins. As the carbon coating increases in thickness the cooling rate for the atmosphere diminishes as does the atmosphere flow rate. Both of these degradations adversely affect the cooling rate of the parts, which in turn reduces part hardness. Long-term degradation of sinter hardened part properties occurs as the carbon buildup increases in the heat exchanger.

Summary

Part delubrication, arguably the most critical step in the sintering process, requires certain time, temperature and atmosphere design. To ensure proper de-lubrication the part must be maintained in a temperature range of 260-510°C (500-950°F) for sufficient time for the lubricant to vaporise and leave the part.

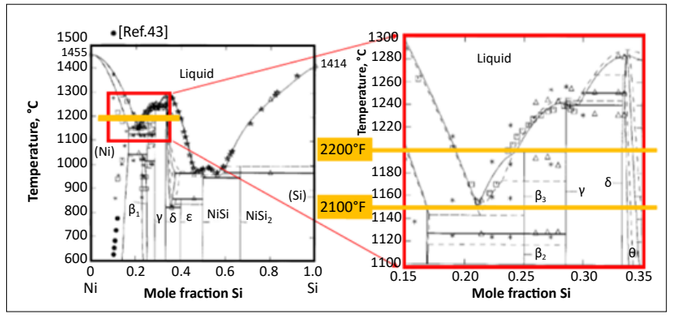

Fig. 5 Silicon (Si) nickel (Ni) phase diagram

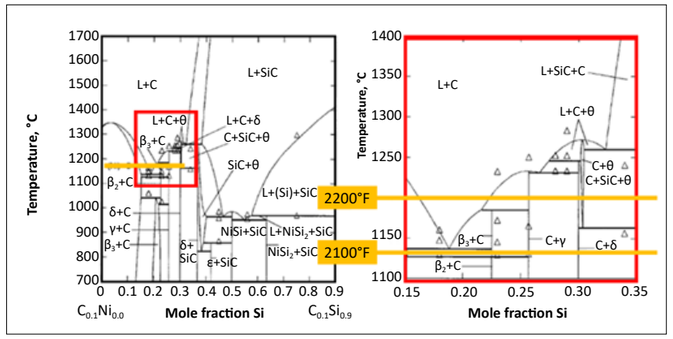

Fig. 6 Silicon (Si), nickel (Ni), carbon (C) phase diagram

While some parts makers have found positive outcomes with the use of accelerated delubrication systems (ADS), adjustment of these units can be difficult and time consuming in order to tune in the process. More common (especially in North America and Europe) is the use of longer delube preheat chambers or zones.

Whatever the length, during this period of vaporisation the atmosphere must contain sufficient oxygen to combine with the escaping carbon atoms so that CO_2 forms and flows out of the furnace. Failure to achieve these conditions will result in the formation of soot, causing a variety of problems for both part quality and furnace life.

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Holzapfel's Sinter Surface Solutions: A reliable process for impregnating and plating PM components

Powder Metallurgy has numerous technological advantages for the production of structural components. However, the process has certain disadvantages when it comes to surface finishing. Sinter Surface Solutions, a two-stage method developed by the Holzapfel Group, is reported to offer a reliable process for the impregnation and subsequent plating of sintered materials. In this article, Michael Immel, Innovation and Project Manager, Holzapfel Group, explains the process.

The Holzapfel Group, headquartered in the German town of Sinn, around an hour north of Frankfurt, was originally founded in 1949 by Willy Holzapfel. Today, the company focuses on the automotive industry, providing it with anti-corrosive and functional coating materials for medium and large series.

There are many situations where Powder Metallurgy components require surface coatings, such as electroplating, to add functionality and protection. However, due to the inherent porosity of the Powder Metallurgy process, it is necessary to seal a component's surface prior to successful plating. Although a number of options exist for this sealing process, many of these have been adapted from other technologies, such as casting, and can lead to inconsistent results. Identifying the need for a system built specifically for the Powder Metallurgy process, Holzapfel has developed Sinter Surface Solutions. The two-stage method offers a reliable process for the impregnating and subsequent plating of sintered materials (Fig. 1).

The issue of porosity

Powder Metallurgy structural components tend to absorb the liquids used during the surface finishing process, such as electroplating, and gradu-

Fig. 1 Sintered parts treated with Sinter Surface Solutions, a process that impregnates the part and leads to successful coating of sintered materials

Fig. 2 The defect known as bleed-out, i.e. salt deposits on the surface of a component

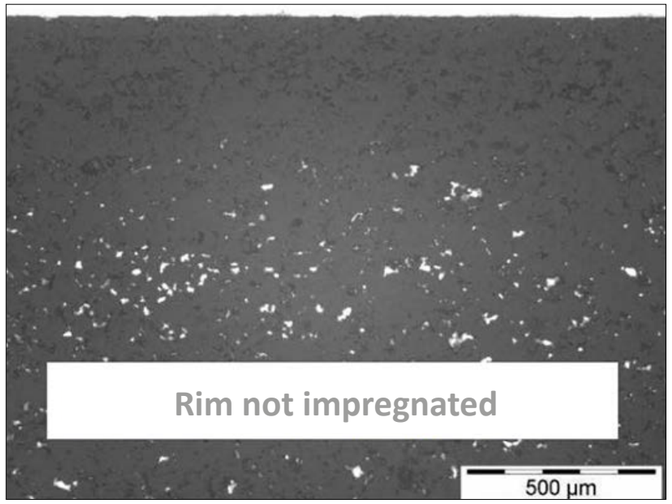

Fig. 3 A special preparation and imaging process makes it possible to portray the extremities of the sintered component with insufficiently filled pores using an incident light microscope

ally release them in the course of time. The resulting defect is known as bleed-out. In the case of electroplated surfaces, such as zinc or zinc-alloy processes, this phenomenon frequently results in salts being deposited on the surface. In most cases, these salts also attack the plating, leading to local corrosion of the plating material.

> *"The porous structure of the sintered materials has a direct impact on the results of subsequent plating processes..."*

The subsequent leakage is due to the porous structure of the sintered materials, which can be likened to a pile of marbles. The grains of the sintered material do not lie completely flush on top of one another, but only touch at certain points to form a cavernous or spongelike network of pores. The size of these pores depends on the shape and size of the powder used in the sintering process and the compressed and/or sintered density of the material.

Impact of the porous structure

The porous structure of the sintered materials has a direct impact on the results of subsequent plating processes, as capillary forces cause the porous structure to absorb liquids when exposed to them, such as during electroplating with galvanic finishings such as zinc- or zinc-alloy processes. The liquids (e.g. degreasers, electrolytes), which are mostly saline, leak out of the openings in the pores after the process has been completed and deposit themselves visibly on the surface. The partially alkaline materials attack the coating metals, leaving behind localised superficial corrosion damage (Fig. 2).

Impregnation: the process of surface sealing prior to treatment

In order to counteract the process of liquid absorption, the network of pores is either closed or sealed off using synthetic resin or similar materials prior to surface treatment. This process is known as impregnation, due to its ability to fill and therefore seal cavities and even micropores in a range of materials. The main reason for impregnation is to produce sealed components. Impregnation is therefore used to prevent leakages, avoid bleed-out, or reduce the incidence of trapped moisture. Impregnation is a pre-treatment required for subsequent surface treatments such as plating and facilitates workability and machining. Impregnation therefore enables materials produced by means of Powder Metallurgy to be used in new types of application for which they would have been unsuitable without a sealing process.

Conventional processes from the casting industry

Various methods are available for impregnating sintered materials. Impregnation processes for these types of material have their origins in the casting industry. Cast components are impregnated in order to seal them against leakage. Without this sealing process, many of the castings would be substandard.

Due to increasing demand, the processes used in the casting industry were employed in parallel for impregnating sintered materials. However, the success in impregnating sintered materials that were to be subsequently plated proved to be both limited and inconsistent. An important factor for materials requiring subsequent plating is that the pores are completely filled right up to the surface and not only somewhere in the depths of the material, as is the case with cast materials.

Tests executed by Holzapfel Group show that when conventional immersion methods for impregnating sintered materials are used, approximately 3–5% of the pores remain unfilled, mainly on the periphery of the component (see Fig. 3). This unfilled rim is approximately 0.2–0.4 mm in size and explains the poor results achieved when applying surface finishes to conventionally impregnated sintered materials, particularly when alkaline alloying techniques such as zinc-iron or zinc-nickel are used.

A process specially designed for sintered materials

With these points in mind, experts at the Holzapfel Group turned their attention to researching the impregnation process, in order to develop an approach to improving it. It soon became clear that conventional impregnation processes in current use inevitably lead to poor plating results, due to process-related necessities.

In order to achieve satisfactory surface finishing results, the impregnation process and the resins utilised need to be coordinated to meet the requirements of the surface that will subsequently be plated. The key innovation of the Sinter Surface Solutions process is the adaptability of the curing process, which ensures that the pores are reliably impregnated to cover the entire surface of the component. The changed curing process is crucial to ensuring reproducibility, as the pores are almost completely filled to the surface of the component without depositing residues of resin that could disrupt the process. This is achieved by ensuring that the resin inserted in the pores begins to harden from the interface surface at the entrance of the pores towards the inside. The droplet formed closes the pore on the outside and prevents the resin from bleeding out, similar to a cork in a bottle. The underlying reaction mechanism of this innovation differs from the currently used conventional systems in that all of the factors that could lead to the resin bleeding out of the pores have been eliminated.

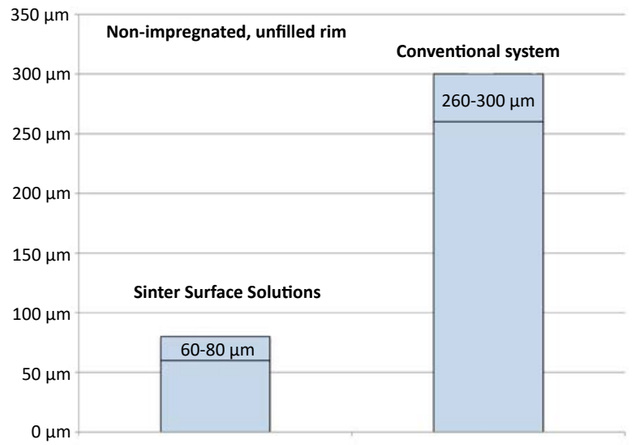

Fig. 4 A sintered product treated with Sinter Surface Solutions has a far thinner rim than a sintered component that is impregnated and coated using conventional methods. This shows that the process makes it possible to produce components with greater reliability and proves the success of the coordinated processes

Reliable impregnation and subsequent plating

The width of the non-impregnated rim has been reduced by 70-80% and is now approximately 60-80 µm on average. The entire filling volume of the pores has been increased by up to 99.8% (Fig. 4). This improvement in the quality of the impregnated components is reflected in the plating results. A reduction in the failure rate from 19% down to 0% for a current series component clearly demonstrates the advantages of the Sinter Surface Solutions system compared with conventional impregnation systems (Fig. 5).

Coordinating the process chain

When it comes to establishing a stable process, a single innovation at the impregnation stage is not sufficient. The entire process chain, including the sintering, the impregnation and the plating process, needs to be coordinated so as to satisfy the requirements of both the component and its plating. In most cases, the processing steps currently performed can all be retained. Sometimes, however, it makes sense to adapt the processing sequence in order to greatly improve plating results. Simply changing the sequence of the process, i.e. performing mechanical processing after impregnation instead of beforehand, significantly improves plating results and also greatly lengthens tool life in mechanical processing.

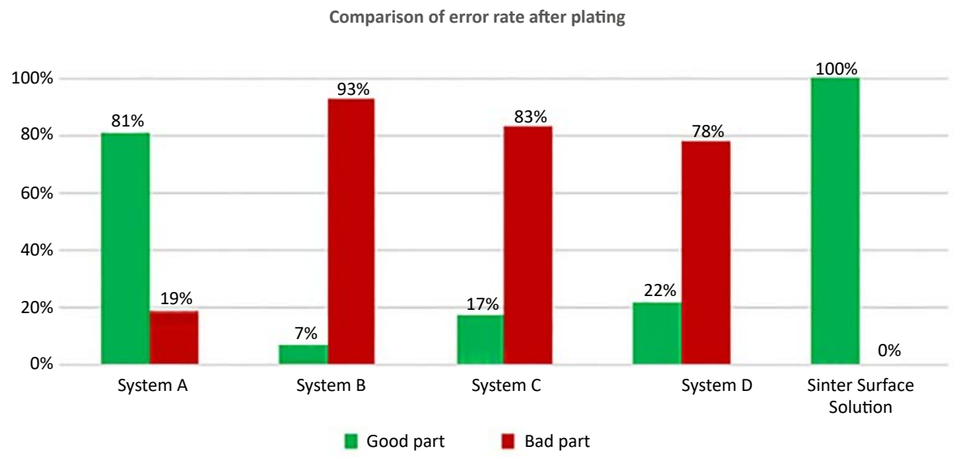

Fig. 5 Comparative test of five different impregnation systems. All components were impregnated and plated using production equipment under series conditions. The assessment was conducted after plating on the basis of plating imperfections (test scope: approx. 3,000 parts)

Another crucial influencing factor is to adapt the plating process to suit the type of sintered material. The success of Sinter Surface Solutions is based on optimising the plating process to suit each particular material. The Sinter Surface Solutions process specially developed for sintered materials makes it possible to impregnate and subsequently plate all widely used types of sintered materials for structural applications. Following impregnation, corrosion-protecting platings such as zinc or zinc-alloy systems can be applied, including decorative platings such as copper-nickel-chrome and other high-quality surface finishes. Functional platings can also be applied to improve properties such as hardness, resistance to chemicals, electrical conductivity or abrasion resistance. A wide range of alloys based on both ferrous and non-ferrous metals can be impregnated.

"The Sinter Surface Solutions process specially developed for sintered materials makes it possible to impregnate and subsequently plate all widely used types of sintered materials for structural applications"

Applications

The impregnation method is relevant wherever liquid corrosive processes are employed and where they could therefore result in subsequent bleeding, even in cases where liquids are used in pre-treatment processes. If a component is unintentionally exposed to oil or lubricants, such as cooling lubricants during machining, an upstream impregnation process can also prevent the component from becoming contaminated and improve tool life.

Case study: Intricate locking disc

A good example of the success of the two-stage process is an intricate locking disc designed by GKN Sinter Metals for a passive pedestrian protection application and manufactured using Powder Metallurgy (Fig. 6). Sinter Surface Solutions made it possible to reliably impregnate and coat this component.

The locking disc is part of a passive pedestrian protection system, i.e. a system that serves to minimise the consequences of an accident, such as injuries. In case of a head-on or similar collision with a pedestrian, the locking disc actuates a mechanism that causes the bonnet of the vehicle to spring open just below the windscreen. The bonnet thus cushions the impact and reduces the risk of the pedestrian's head, for example, colliding with hard parts of the engine.

The amazingly intricate disc fulfils an essential unlocking function and it is therefore all the more important that this component remains functional throughout the life cycle of the vehicle. Here, corrosion resistance plays a key role, particularly in the exposed engine compartment area. Although zinc-nickel and similar platings are commonly used to protect components from corrosion in engine compartment applications, intricate parts such as this locking disc can't easily be manufactured using cutting or milling techniques. For that reason, the locking disc and the cams that interlock and connect in the event of a collision are manufactured using Powder Metallurgy.

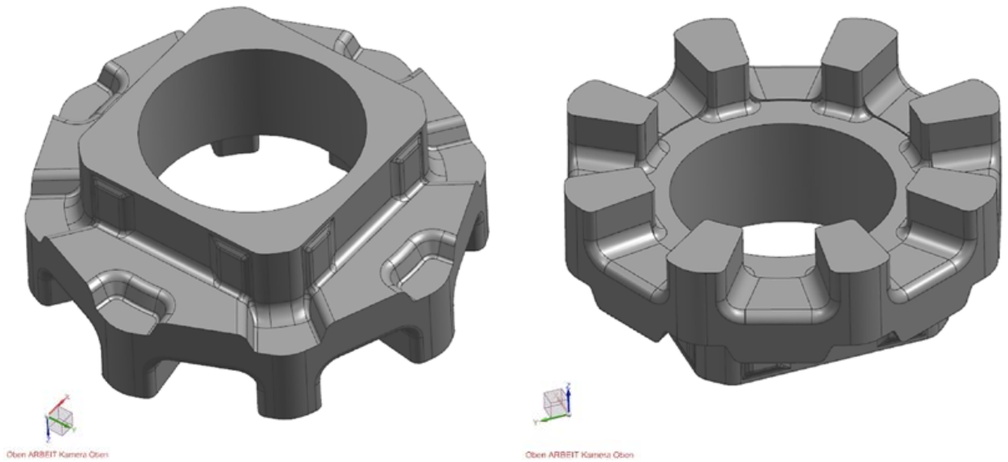

Fig. 6 The intricate locking disc designed by GKN Sinter Metals actuates an unlocking mechanism for vehicle bonnets in a passive pedestrian protection application and is manufactured using a Powder Metallurgy process

Intricate structure guarantees functionality

GKN Sinter Metals manufactures the locking disc for Edscha, a well-known automotive supplier in Bavaria, Germany, which developed and produces the complete component for unlocking the vehicle's bonnet. In order to manufacture the locking disc with varying heights (cams) without compromising the stability, the pressing technology had to be improved. Moreover, the manufacturing process is continually monitored, which means that the parts do not need to undergo addition testing. Another significant point was the strict corrosion- and temperature-resistance requirements for use in the engine compartment. The required contour precision made a zinc flake coating system unsuitable, leaving galvanic plating as the only other possible solution. The locking disc was therefore given a zinc-nickel plating in order to meet all of the manufacturer's requirements.

Custom Sinter Surface Solutions option

GKN's experts had previously experienced sporadic problems, such as bleed out, on other components impregnated using conventional processes followed by zinc-nickel coating.

For that reason, the locking disc could not be reliably produced using a conventional impregnation process and a Sinter Surface Solution was selected using a customised impregnation and plating system adapted to suit it. A special zinc-nickel process that ideally matched the specifications of the locking disc was used in the modified plating process. This combination proved to be highly successful, as both the impregnation and the plating are specially designed for the component and guarantee a zinc-nickel plating with flawless layer growth. The benefit for the customer is clear-cut: the impregnation and plating made possible by the use of Sinter Surface Solutions enabled the component to be manufactured using the desired base material and the required surface.

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