VOL. 8 NO. 3
AUTUMN/FALL 2019

POWDER METALLURGY REVIEW

FUKUDA METAL FOIL & POWDER

NICHOLS PORTLAND

LOW-COST TITANIUM VIA PM

Published by Inovar Communications Ltd

www.pm-review.com

Publisher & editorial offices
Inovar Communications Ltd
11 Park Plaza
Battlefield Enterprise Park
Shrewsbury SY1 3AF
United Kingdom

Editor & Publishing Director
Paul Whittaker
Tel: +44 (0)1743 211992
Email: paul@inovar-communications.com

Managing Director
Nick Williams
Tel: +44 (0)1743 211993
nick@inovar-communications.com

Deputy Editor
Emily-Jo Hopson
emily-jo@inovar-communications.com

Assistant Editor
Kim Hayes
kim@inovar-communications.com

Consulting Editor
Dr David Whittaker
Consultant, Wolverhampton, UK

Advertising Sales Director
Jon Craxford
Tel: +44 (0) 207 1939 749
jon@inovar-communications.com

Production
Hugo Ribeiro, Production Manager
Tel: +44 (0)1743 211994
hugo@inovar-communications.com

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

Please contact Paul Whittaker, Editor
Email: paul@inovar-communications.com

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

The long history of Powder Metallurgy

In this issue we report on two long established Powder Metallurgy companies, both with rich histories, but from different ends of the process chain and from different continents.

One of the oldest manufacturers in Japan, and one of the earliest producers of metal powders in the world, Fukuda Metal Foil and Powder Co Ltd has been established for over three hundred years. Testament to a strong managerial ethos, the company continues to develop new materials to meet the demands of today's industry.

Also established for many years, and still meeting the needs of today's industry, is Nichols Portland. The company is widely known for its development of gerotors, which it has been producing for over 85 years. It began using Powder Metallurgy in the 1970s, and today draws on its unique experience to produce PM components for many end-user sectors.

Proof that innovation in the industry remains strong, the MPIF's 2019 Design Excellence Awards showcased the many advantages that Powder Metallurgy can bring as a manufacturing process. The benefits of part production from metal powder are many, and in a changing market these advantages could be key to the future prosperity of the industry.

Paul Whittaker
Editor, *Powder Metallurgy Review*

Cover image
Fukuda offers over 1000 metal powder products (Courtesy Fukuda Metal Foil and Powder Co., Ltd,)

Kymera INTERNATIONAL
Pioneers in Material Science

About Kymera International:

With nine manufacturing sites in seven countries, Kymera International is a global leading producer and distributor of powders, pastes and granules of aluminum, aluminum alloys, copper, copper oxide, bronze, brass, tin and several specialty alloys.

 www.kymerainternational.com

POWDER METALLURGY REVIEW


33


63


72


86


94

in this issue

regular features

industry news

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

Paper submissions now open for WorldPM2020 in Montréal

In 2020, the World Congress on Powder Metallurgy & Particulate Materials (WorldPM2020) is heading to Montréal, Canada, from June 27–July 1, 2020. Taking place every two years, the series rotates between North America, Europe and Asia, bringing together the global Powder Metallurgy community for the largest event in the industry.

The Metal Powder Industries Federation (MPIF), organiser of the 2020 congress, has issued a call for papers and posters for the technical programme. 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 Powder Metallurgy parts.

In addition to the conference, there will be a major exhibition featuring a wide range of international exhibitors and providing an opportunity for networking with material and equipment suppliers, part producers and end-users.

Co-located events to bring added value to the World Congress

Co-located with WorldPM2020 will be the 2020 Additive Manufacturing with Powder Metallurgy conference (AMPM2020) and the 10th International Conference on Tungsten, Refractory & Hardmaterials (Tungsten2020), both taking place over the same days and allowing even greater interaction across the metal powder-based industries.

According to the MPIF, the AMPM conference has grown significantly since its debut in 2014 as the only conference focused solely on metal Additive Manufacturing, and in 2020 will feature an extra day of technical sessions. Topics will include process modelling, design of components, powder production, post-build operations, materials and testing.

The Tungsten2020 conference aims to address recent developments in the refractory and hardmetals field and will encompass refractory and hardmetal processing, microstructure, properties, and applications. Papers are requested on topics including powder production, processing, mechanical behaviour and modelling.

Montreal will host WorldPM2020, in conjunction with the AMPM2020 and Tungsten2020 events (Courtesy Artur Staszewski)

Call for papers

Those authors wishing to present at the WorldPM2020 congress, AMPM2020 or Tungsten2020 should submit their abstracts online no later than November 15, 2019. Full submission guidelines are available via the organiser's website.

www.ampm2020.org
www.tungsten2020.org
www.worldpm2020.org
www.mpif.org

H.C. Starck reports increased tungsten powder sales

H.C. Starck Group, Munich, Germany, has reported a significant increase in its sales for fiscal year 2018, with total sales at €691.7 million. Adjusted to account for the sale of its Tantalum & Niobium and Surface Technology and Ceramic Powders (STC) Divisions during the year, sales were said to have risen by 23% to €581.7 million.

The company stated that the most important external factor was a positive economic environment in the end-user industries. Enhanced sales efforts, advances in technology and productive cost initiatives were also said to have contributed to its success.

H.C. Starck's tungsten division, H.C. Starck Tungsten GmbH, posted an increase in sales in 2018 said to reflect the market success of its nanocrystalline tungsten carbide varieties and the ongoing ramp-up of capacity at its Chinese plant. Numerous projects designed to help increase efficiency, such as the optimised utilisation of worldwide plant capacities and the improvement and development of various production processes, were also key to its performance.

As a result of investments made to increase capacity and tap into new business segments, H.C. Starck stated that it expects the positive trends within the individual divisions of the group to continue in the current fiscal year.

www.hcstarck.com

Sandvik President and CEO to depart company in February

Björn Rosengren, President and CEO of Sandvik AB, Stockholm, Sweden, has informed the Chairman of the Sandvik Board that he intends to resign and will leave the company as of February 1, 2020. He will now join ABB, a multinational automation corporation headquartered in Zurich, Switzerland.

Johan Molin, Chairman of the Board for Sandvik, stated, "Björn Rosengren has, since he joined Sandvik in November 2015, established a solid decentralised business model for the company and made the organisation more flexible and efficient."

"The board is very grateful for his and all the employees' work during these years," he continued. "We will initiate the process to assign a very experienced and competent industrial leader that can succeed Björn in the role as President and CEO and continue to develop the company even further."

"This has not been an easy decision," commented Rosengren. "Sandvik is a great company with a lot of future potential and I will continue to lead the organisation with a strong commitment until the end of January."

www.home.sandvik

Miba takes stake in battery systems manufacturer Voltlabor

Miba AG, Laakirchen, Austria, has taken a 25.1% stake in Voltlabor, a sister company of Nordfels GmbH, headquartered in Bad Leonfelden, Austria. The company specialises in the development and production of batteries for electric drives.

According to Miba, the complementary expertise of the two companies will be pooled in order to leverage opportunities for growth, with the goal of creating an important player for the development and production of battery systems worldwide. Activities will be centred on technologically sophisticated niches in which it believes Voltlabor has a clear lead.

While Voltlabor has built up a lot of expertise as a manufacturer of battery systems through its lifetime, Miba has specialised in component development and production. The company stated that it will make its technologies for the thermal management of batteries, which contribute substantially to the optimum functioning of the battery as a whole, available to the joint venture.

One such technology is FLEXcooler®, a flexible battery cooling system that can adjust its shape to fit battery cells. Miba will also reportedly contribute its expertise in the industrialisation of production processes, its access to customers and markets around the world and its production capabilities on four continents.

Voltlabor will continue to operate out of Bad Leonfelden. Depending on how business develops, it was stated that further sites may be added in key markets. Stefan Gaigg, Head of Business Unit Battery Components at Miba eMobility, has been appointed as Managing Director of Voltlabor.

F Peter Mitterbauer, Miba CEO, stated, "The battery is the centerpiece of electric drives. Miba has already developed a number of solutions for thermal management of batteries. Investing in Voltlabor to expand our expertise toward complete battery systems is the next logical step. By taking a stake in Voltlabor, Miba is continuing its strategy of being proactively involved in the electrification of drives in line with its vision 'No powertrain without Miba technology.'"

"Having Miba as a partner will enable us to set the scene for future growth in all key customer markets worldwide," added Johannes Kaar, Voltlabor's co-founder and CFO of Nordfels GmbH. "By pooling our expertise we can take advantage of opportunities and develop the company together."

www.miba.com
www.nordfels.eu

Plansee Group reports record sales results

The Plansee Group, headquartered in Reutte, Austria, has reported the results for its 2018/19 fiscal year ending on February 28, 2019. The group reported that it achieved a consolidated sales revenue of €1.52 billion, marking a 17% year-over-year increase and a new record for the group.

All sales markets and regions, as well as all of the Plansee Group's divisions and companies, were said to have contributed to this sales growth. Regionally, 53% of revenue came from Europe, 25% from the USA, and 22% from Asia. Drill manufacturer Komet, acquired in 2017, contributed one third to the group's increased sales. Total sales volume was reported to have risen by 7%.

Bernhard Schretter, Plansee Group Executive Board Member, stated, "In a very exciting market environment, we differentiated ourselves through flexibility and strength." Schretter and Karlheinz Wex, also a Member of the Executive Board, added that, in light of an equity ratio of 58%, the Plansee Group is debt-free and equipped for economic fluctuations as well as additional development steps.

During a press conference in Reutte, Schretter and Wex described the course of the fiscal year as a year "with two faces." The first half of the year was said to have seen "immensely high demand," while business notably slowed in the second half of the year, particularly in the months of December 2018 and January 2019.

"Our continued goal must be to meet fluctuating demand and the rising competitive pressure from China with flexibility and strength," added Wex. As a result, the group has made continued investments in its performance capability in the past year and took important steps to expand its recycling rate and employee training.

Over the course of the fiscal year, Plansee reported that it had invested €210 million in strengthening its performance capability. The majority of investments went toward creating new and expanding existing production capacities and automating production plants and flows, focusing primarily on its manufacturing sites in China, India, Austria, Germany, Japan and Switzerland.

The group also invested a total of €67 million in the development of new products and process improvements. New products (products less than five years old) accounted for 29% of sales revenue, the same level as in the previous year. The organisation in the Plansee High Performance Materials division was also said to have been extensively streamlined to reduce interfaces and facilitate growth.

In view of volatile raw materials markets and difficult general conditions for tungsten mines in the West, Plansee stated that it had taken further steps to safeguard the raw material supply of tungsten in the long run. On March 1, 2019, Plansee announced the acquisition of Stadler Metal, a German company specialising in the trade and processing of hard metals.

Wex explained, "Hard metals are made of tungsten and cobalt. Demand for these metals is on the rise worldwide. Stadler purchases used hard metal tools and analyses and sorts them." The acquisition is expected to further increase the recycling rate of tungsten in the Plansee Group from its current 60%. The group's capacity for recycling hard metal scrap to yield fresh, usable tungsten and cobalt powder is also being expanded at its locations in Finland, the USA and Austria.

Following major fluctuations in demand in the past fiscal year, the company reported that demand has levelled off in the first quarter of the current fiscal year to a slightly lower, but stable rate.

"At present, we expect the business environment to remain at this level in the coming months," stated Wex. It was noted that the group is not directly affected by Brexit and unforeseeable trade conflicts, but Wex added that "in the long run these developments hurt the entire economy. To remain successful in the future, we will stick to our clear focus on tungsten and molybdenum materials for high-tech applications, create the conditions for excellently trained employees, and continue to invest in our performance capability, and in skills and processes in particular, to be the preferred supplier for our customers."

www.plansee.com

Kennametal fiscal year 2019 results, announces three production facilities to close in Germany and USA

Kennametal Inc., Pittsburgh, Pennsylvania, USA, has announced its fourth quarter and full fiscal year results for 2019. In further news, the company also announced plans to close manufacturing facilities in Irwin, USA, Essen, Germany and Lichtenau, Germany, along with its distribution centre in Neunkirchen, Germany.

In the fourth quarter 2019, the company reported sales of $604 million, down 7% from $646 million in the same quarter 2018. Full-year sales were reported at $2,375 million, up 3% from $2,368 million for the full year 2018. According to the company, the decrease in sales in the fourth quarter 2019 was driven by unfavourable currency exchange, organic decline and fewer business days. The slight growth in sales for the full fiscal year 2019 was offset by unfavourable currency exchange of 3%.

Operating income for the quarter was $85 million, compared with $94 million in the fourth quarter 2018. Adjusted operating income was said to be $95 million, compared with $99 million in Q4 2018. Net income attributable to Kennametal was $61.9 million, down from $68.5 million in the same period 2018.

For the full year 2019, operating income was reported to be $329 million, compared with $290 million in the previous year. Adjusted operating income was $346 million, compared with $306 million in the previous year.

"We posted strong margin improvement in fiscal 2019 on moderate organic sales growth, reflecting increasing progress on our simplification/modernisation initiatives," stated Christopher Rossi, President and Chief Executive Officer of Kennametal.

"Against this backdrop of year-over-year progress, we saw increased softening in most of our end-markets late in the year, which put pressure on our fourth-quarter results. Our expectation is that this challenging macro environment will continue into the first half of fiscal 2020. Nevertheless, we will stay focused on the things we can control and execute our plan to improve long-term profitability," Rossi continued.

Kennametal plans restructuring

Kennametal also announced several restructuring actions, said to position it for long-term profitable growth. The company plans to close its manufacturing facilities in Essen and Lichtenau, Germany; its distribution centre in Neunkirchen, Germany; and its manufacturing facility in Irwin, Pennsylvania, USA. These restructuring actions are expected to aid the company in securing its fiscal 2021 financial targets.

They are also part of the previously announced goal of reducing plants through simplification/modernisation, with additional plants currently under evaluation. The proposed restructuring will be executed over the next two years, and is expected to deliver estimated annualised savings of $35–40 million and $55–65 million in pre-tax charges.

"The proposed measures are difficult but necessary to achieve structural improvements, further improve operational efficiency and continue to drive value for shareholders," stated Rossi. "We recognise the effect on our employees and will work closely with their representatives to support them throughout this transition."

The company plans to consolidate its Essen and Lichtenau operations, including both Kennametal and WIDIA-branded products, into other lower-cost Kennametal industrial facilities. The Irwin operations would be consolidated primarily into the newly modernised infrastructure plant in Rogers, Arizona, USA.

www.kennametal.com

Rare earths producer Northern Minerals enters agreement with thyssenkrupp

Northern Minerals Limited, a heavy rare earths (HREs) producer based in West Perth, Australia, has entered into an offtake agreement with thyssenkrupp Materials Trading GmbH, Essen, Germany. The new deal is for 100% of offtake from the Browns Range Pilot Plant Project, located in northern Western Australia, and replaces the company's previous agreement with China's Liangyugang Zeyu New Materials Sales Co. Ltd, terminated earlier this month.

The move offers the flexibility for the company to supply HREs as separated products in the future, as well as covering the intention of the two companies to work together on the implementation of separating technologies at Browns Range and on potential future expansions of the project.

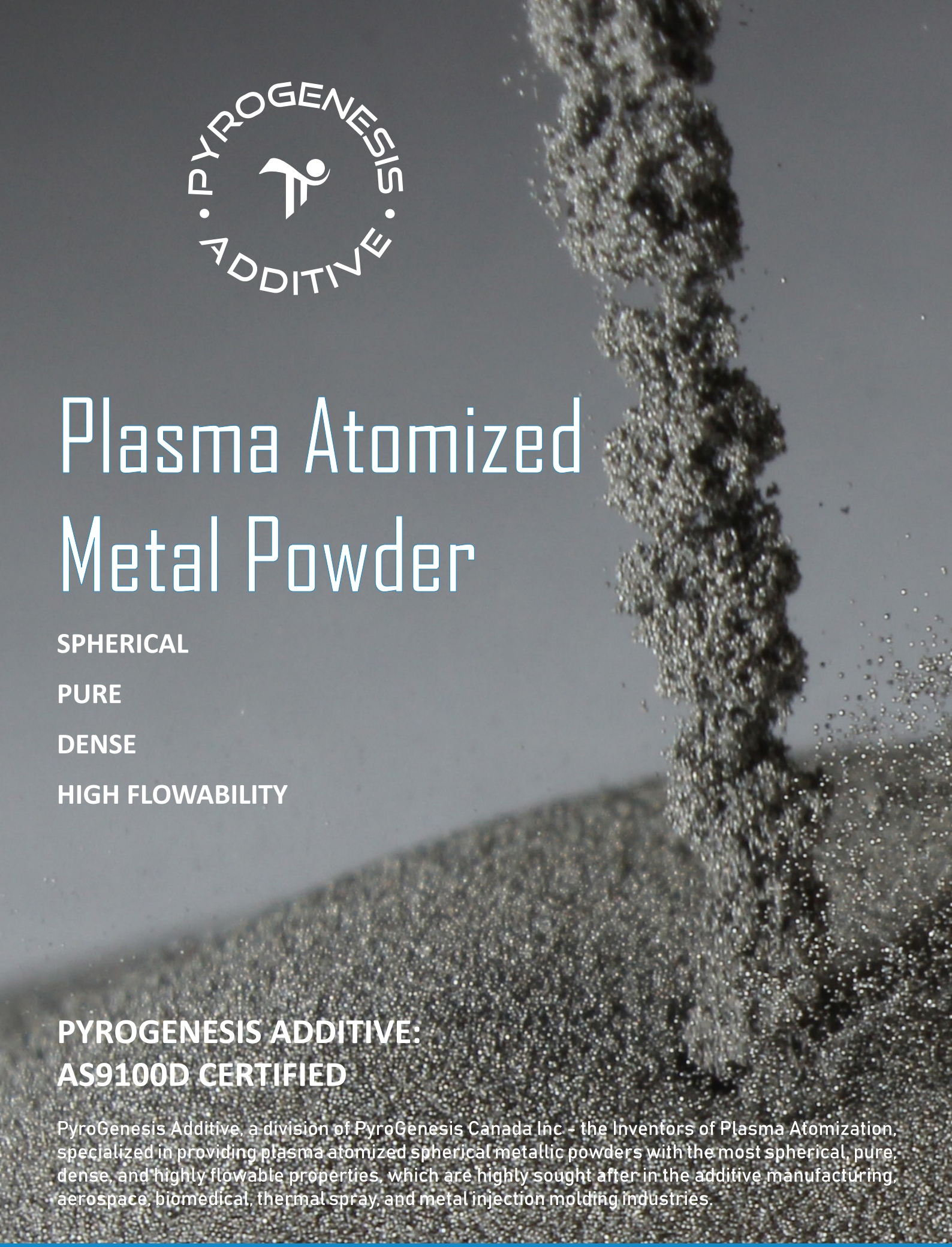
Rare earths are seen as an increasingly important resource, as industries seek to produce products which are smaller, lighter and more efficient. They are a key component in the manufacture of clean energy and high-end technology solutions. Currently, China controls around 90% of the global rare earths market, due to the high concentration of rare earth deposits within its borders. With its exploration of rare earth deposits located at Browns Range, Northern Minerals believes that it has the potential to become the first significant producer of the rare earth element dysprosium outside of China. Dysprosium's primary use is in alloys for neodymium-based magnets, which are used in motors and generators such as those in hybrid and electric vehicles and wind turbines.

Wolfgang Schnittker, CEO of thyssenkrupp Materials Trading, commented, "Northern Minerals Limited is one of the few suppliers of rare earths outside China, so we are really looking forward to a successful collaboration between the companies. As the exclusive marketer of these high-quality products we have the opportunity to strengthen our customer relationships long-term and expand our positioning in this field."

George Bauk, Northern Minerals' Managing Director and CEO, stated, "The new offtake agreement with a global player such as thyssenkrupp is a significant endorsement of Browns Range and the company. The continued shift of new car sales to electric vehicles is gaining traction, with all major car makers introducing EV variants of existing models over the coming years. With this shift, both car and component makers are accelerating plans to invest further down the production chain in order to secure surety of supply."

www.thyssenkrupp-materials-trading.com

www.northernminerals.com.au



Plasma Atomized Metal Powder

SPHERICAL

PURE

DENSE

HIGH FLOWABILITY

PYROGENESIS ADDITIVE: AS9100D CERTIFIED

PyroGenesis Additive, a division of PyroGenesis Canada Inc - the Inventors of Plasma Atomization, specialized in providing plasma atomized spherical metallic powders with the most spherical, pure, dense, and highly flowable properties, which are highly sought after in the additive manufacturing, aerospace, biomedical, thermal spray, and metal injection molding industries.

CONTACT US:

T. +1 514 937 0002 • F. +1 514 937 5757

www.pyrogenesis.com/products-services/contact-pyrogenesis-additive/

Eisenmann files for insolvency in bid to accelerate strategic reorientation and restructuring

Eisenmann SE, Böblingen, Germany, has filed a petition for the opening of insolvency at Stuttgart District Court with the aim of accelerating the restructuring and strategic reorientation of the Eisenmann Group, which began in March 2019. Applications were also submitted to Eisenmann Anlagenbau GmbH & Co. KG, Eisenmann Lactec GmbH and ENisco GmbH & Co. KG.

Dr Michael Keppel, Chief Restructuring Officer of Eisenmann SE, stated, "We are focusing on our core business and intend to push forward the restructuring and strategic realignment of the Eisenmann Group as part of the insolvency in order to return to a profitable business as soon as possible. We want to use this opportunity for a fresh start consistently and can build on a fundamentally sound business model. Market position, reputation, innovative strength and motivated and well-trained employees are essential components for the long-term perspective of our company."

Keppel added that the Board of Directors, the Eisenmann family and the lenders support the path that has been taken. The owner and management of the Eisenmann Group initiated the restructuring and strategic reorientation of the company in March 2019. It was reported that the acquisition and completion of various major projects in 2018 had led to a large year-on-year loss.

"We had to act fast and consistently here. At the same time, we also wanted to create the strategic and structural foundations for our long-term competitiveness," Keppel added. "We are convinced that we can shoulder the growing risks and capital requirements in our systems business together with an industrial partner and exploit our full potential more quickly. That's why we're looking for a strategic partner for our Paint & Assembly (PA) and Application Technology (AT) businesses. First interested parties have already registered."

Eisenmann has a workforce of approximately 3,000 worldwide, with 27 locations in 15 countries in Europe, the Americas and the BRIC countries. In 2017, Eisenmann generated annual revenues of €723 million euros.

www.eisenmann.com

GKN Powder Metallurgy opens new customer centre in Bonn

GKN Powder Metallurgy has opened a new customer centre in Bonn, Germany, at which customers and partners can receive support and training in all aspects of Powder Metallurgy and metal Additive Manufacturing. The opening is the third in a year which has seen the company launch customer centres in Danyang, China, and Auburn Hills, Michigan, USA.

The new customer centre in Bonn (Courtesy GKN Powder Metallurgy)

The customer center is expected to allow GKN Powder Metallurgy to host tailored visits for customers and business partners to meet their specific interests. Visitors to the site can also explore the integrated innovation showroom, with showcases featuring the full range of GKN Powder Metallurgy's technology strategy, and take advantage of its spacious conference and training rooms for hands-on workshops.

"Today, emerging countries can manufacture products of the highest quality. This means we have to further accelerate innovation in Germany," stated Guido Degen, President Additive Manufacturing at GKN Powder Metallurgy. "Our experience centres are an ideal platform for intensifying partnerships with our customers and strengthening collaboration. By discussing specific business challenges and evolving industry trends, we can identify areas of growth potential together."

"We have great confidence we're heading in the right direction because we are working with the world's most amazing companies," added Peter Oberparleiter, CEO at GKN Powder Metallurgy. "We're developing groundbreaking products with our customers, refining 3D printing processes with our partners like HP Inc. and EOS, and creating our own digital solutions driven by the collective ingenuity of our people. GKN Powder Metallurgy's focus on innovation will allow us to strengthen our position in the market even more in the future. "

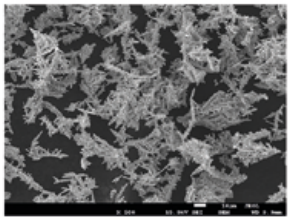
GKN Powder Metallurgy employs more than five-hundred people at its IATF 16949-certified production site in Bonn, which was founded in 1934. The facility currently produces over seven million parts per week.

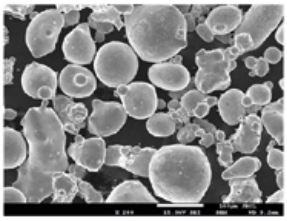
www.gknpm.com

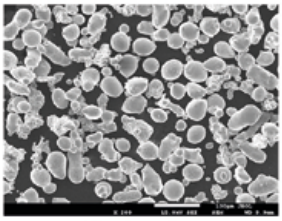
Gripm
有研粉末

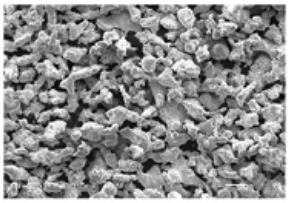
A Global Supplier of Non-Ferrous Metal Powders with a Reputation for

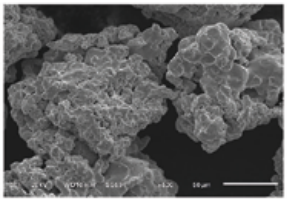
· QUALITY · FLEXIBILITY · CUSTOMER SERVICE · NEW PRODUCT DEVELOPMENT

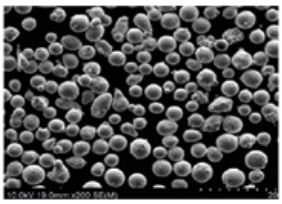

Electrolytic Copper Powder


Atomized Copper Powder


Tin Powder


Copper Alloy Powder


Diffusion Powder


3D Printing Copper Alloy Powder

Products Include

- **Copper:**
  - –irregular
  - –spherical
  - –dendritic
- **Copper alloys**
- **Tin**
- **Press-ready premix bronzes**
- **Infiltrants**
- **Speciality powders**

GRIPM Advanced Materials Co., Ltd., in Beijing, China, since 2004 (former factory from 1997), held by GRINM Group Co., Ltd (a Chinese national corporation group since 1952)
Annual capacity: > **30000MT**
FIVE subsidiary companies, including **Makin Metal Powders (UK) Ltd.**

MAKIN METAL POWDERS
A Member of the GRINM Family of Companies

Makin Metal Powders (UK) Ltd has achieved its current position as one of the leading Copper and Copper Alloy powder producers in Europe by supplying the powders that match customer technical specifications in the most cost effective manner on a consistent basis.

GRIPM Advanced Materials Co., Ltd.
TEL: +86-10-61669867 Fax: +86-10-61667989 E-mail: info@gripm.com www.gripm.com

Makin Metal Powders (UK) Ltd.
TEL: +44(0)1706717317 Fax: +44(0)1706717310 E-mail: sales@makin-metals.com www.makin-metals.com

H.C. Starck Fabricated Product Division rebranded H.C. Starck Solutions

H.C. Starck's Fabricated Product Division, headquartered in Newton, Massachusetts, USA, has been rebranded and will now be titled H.C. Starck High Performance Metal Solutions (H.C. Starck Solutions). The company is a global manufacturer of metal powders, complex fabrications, and additively manufactured parts made from refractory metals, and is an independent business division of H.C. Starck Group.

"While remaining a division of the larger H.C. Starck Group, this branding initiative will support the H.C. Starck Solutions division's future orientation towards being a solutions-based provider and strengthen our brand image in the marketplace," stated Andreas Mader, Chief Executive Officer of H.C. Starck Solutions.

H.C. Starck Solutions specialises in the manufacture of key components based on the most robust materials available, including molybdenum, tungsten, tantalum, niobium and their alloys (Courtesy H.C. Starck)

According to the company, as part of the rebranding, H.C. Starck Solutions has launched a new user-friendly website designed to provide users with better access to its range of services and products offered.

www.hcstarcksolutions.com

MPIF's PM Parts Compacting Tooling Seminar to take place in November

The Metal Powder Industries federation (MPIF)'s Powder Metallurgy Parts Compacting Tooling Seminar is set to take place at the Penn Stater Conference Center Hotel in State College, Pennsylvania, USA, from November 19–20, 2019.

The-two day seminar, which runs biennially, covers basic and advanced compacting and tooling technology. Presentations will cover the latest developments in tool design, tool coating and unique press applications, the impact of tool design and press selection on product quality.

An early registration discount is available until October 11, 2019.

www.mpif.org

Höganäs expands powder facilities in Pennsylvania, celebrates twenty years in North America

Sweden's Höganäs AB, is celebrating twenty years since the opening of its offices in North America. The company also announced plans to expand its Johnstown facility in Pennsylvania, USA, with the addition of new metal powder production capabilities.

In 1999, Höganäs established its first offices in Bethlehem, Pennsylvania, USA, after an organisational shake-up resulted in Hoeganaes Corporation in North America being sold. According to the company, when GKN acquired Interlake, an 80% owner of Hoeganaes Corporation, Höganäs and GKN agreed on the sale of the remaining 20% of the shares owned by Höganäs.

The deal opened up the possibility for Höganäs to sell metal powder in the North and South American markets that had been previously reserved for Hoeganaes Corporation. In this new quest, Höganäs acquired a Brazilian metal powder producer and founded a new subsidiary in the US: North American Höganäs.

After the first North American sales office was established, Höganäs states that it went on to acquire a steel plant in Stony Creek, First Miss Steel, and Pyron, an iron powder plant in Niagara Falls. In 2001, the atomising plant was inaugurated and two years later, Höganäs acquired SCM Metals in Johnstown for production of high alloys.

Since 1999, Höganäs has continued to develop and expand its presence in the North American market and recently announced the expansion of its Johnstown facility. The project will include the construction of a 24,000 ft^2 building and the purchase of new machinery.

According to the company, the decision to expand was taken in response to global demand for its high alloy products. Dean Howard, President of Höganäs Americas Continent, stated, "This exciting investment, with the greatly appreciated support from the Governor's Action Team and JARI, will help Höganäs continue to grow in Pennsylvania and provide innovative products for our customers in several quickly developing market areas."

"Pennsylvania's powder metals industry is a major contributor to our manufacturing sector," commented Pennsylvania Governor Wolf. "Höganäs' decision to expand here is great news for Pennsylvania manufacturing, and will provide at least twenty-five reliable, family-sustaining jobs for Cambria County workers."

"JARI is pleased to provide support to Höganäs as the company expands their operations in the City of Johnstown," added Linda R Thomson, President and CEO of the economic development organisation JARI.

www.hoganas.com

GeniCore reports Poland's JG Group's investment in its U-FAST sintering system

GeniCore, a material engineering company based in Warsaw, Poland, has reported that the JG Group Sp. z o.o., an industrial engineering company located in Lublin, Poland, has invested in its U-FAST (Upgraded Field Assisted Sintering Technology) system.

The U-FAST process is said to incorporate the fastest electric pulses available on the market, at under 1 ms, with a modular technology operating in a high vacuum, to produce high performance ceramics, metal matrix composites, super hard materials, functionally gradient materials and MMCs with uniform microstructure and good physical properties.

According to GeniCore, the JG Group is expanding into the processing of ultra-modern materials, and the implementation of various research projects has contributed to the acquisition of extensive knowledge in this field. The company states that conventional systems can be time-consuming and have limited sintering capabilities for materials with different melting temperatures.

The U-FAST technology is also said to significantly reduce production time and energy consumption, as well as allowing for a faster and more cost-effective method to produce complex machine parts. It was stated that the new products produced at JG Group will be widely used in the automotive and aviation industries.

"By deciding to start production using the sintering method based on U-FAST technology, we have reached a milestone in the company's operations," stated the CEO of the JG Group.

www.genicore.pl
www.jg-group.pl

JG Group has purchased one of GeniCore's U-FAST sintering machines (Courtesy GeniCore)

Seco/Warwick Group announces Woźniak as new President of the Management Board

Seco/Warwick, Swiebodzin, Poland, has appointed Sławomir Woźniak as its new President of the Management Board. Woźniak, a graduate of the Institute of Electrical Engineering at the University of Zielona Góra, Poland, began his career at Seco/Warwick as an apprentice electrician. In 2018 he became Vice President of the Management Board at Seco/Warwick S.A. and Chief Operating Officer of Seco/Warwick Group.

"It is a great honour to assume leadership of the company which I have been associated with since the beginning of my professional career," Woźniak stated. "We are facing the extremely important and ambitious task of determining the further directions in which the company should go. Together, we will create a global culture of accountability throughout the entire Seco/Warwick Group's organisation, and involve all the group companies in the fulfillment of our objectives, which will allow us to increase our economy of scale."

"I believe that with such a professional international team of specialists, stable foundations, excellent technologies, proven products and excellent references, it will be possible to create the innovative and reliable solutions that the group is known for, which, in turn, will strengthen our market and financial position," he added.

www.secowarwick.com

Sławomir Woźniak is now President of the Management Board (Courtesy Seco/Warwick)

GF Machining Solutions expands US distribution and sales

GF Machining Solutions, headquartered in Geneva, Switzerland, has announced that its US branch, located in Lincolnshire, Illinois, has expanded its distribution channels and regional sales in North America.

Marcus Machinery is reported to have extended its distribution agreement with GF Machining Solutions to now include all of Pennsylvania, New York, New Jersey, Delaware, Maryland, D.C. and West Virginia.

Midwest Machinery Solutions, formerly the exclusive GF Machining Solutions distributor for northern Illinois, will now take over distribution across the entire state. GF Machining Solutions added that it will now directly oversee sales in Canada under the direction of Sean Smith, Sales Manager.

www.gfms.com
www.marcusmachinery.com
www.midwest-ms.com

Maltese mining group to buy Metalysis out of administration

Power Resources Group (PRG), a mining company headquartered in Valletta, Malta, has announced that it will buy Metalysis, Rotherham, UK, after the company entered administration following financial difficulties in June 2019. According to Reuters, PRG mines tantalum and niobium in Rwanda and has a refinery in North Macedonia.

Metalysis holds the worldwide exploitation rights to the FCC Cambridge process. Developed at Cambridge University in the late 1990s, the solid-state, modular, electrochemical process is said to be able to produce tens-to-hundreds of tonnes of high-value, niche and master alloy powders per annum.

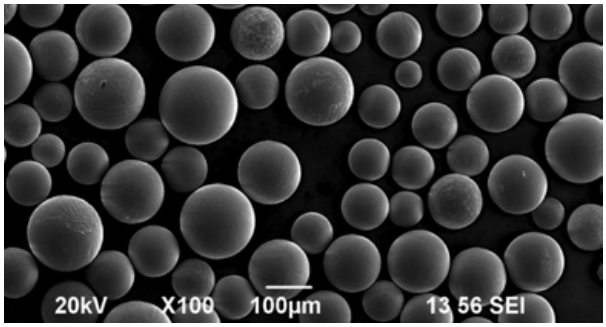
With a Materials Discovery Centre on the Advanced Manufacturing Park (AMP), also in Rotherham, Metalysis announced in March 2018 that it had raised £12 million to fund new state-of-the-art post-processing facilities, the acquisition of feedstock and to provide working capital to support the roll-out of its Gen4 facility, the first to take the FCC Cambridge process to industrial scale. Overall, approximately £25 million was raised by the company to bring the project to completion.

One of the challenges said to have been faced by Metalysis was its reliance on externally sourced materials, the prices of which can be volatile, for the metal powders it produced for the Additive Manufacturing industry.

Ray Power, CEO of PRG, told Reuters that Metalysis had been "just a whisper away from commerciality" when it went into administration and that "the technology metals focus is a perfect complement to PRG's existing vertically integrated mining and refining operations and customer base."

While the companies have declined to disclose financial details of the transaction, PRG will be the sole owner of Metalysis. Eddie Williams of Grant Thornton, joint administrator of Metalysis, said the sale had been "a very challenging process," but he was pleased that jobs had been saved.

www.prgplc.eu | www.metalysis.com



SEM image of Metalysis' spheriodised Ti-6Al-4 powder (Courtesy Metalysis)

Voestalpine secures ten-year contract with Rolls-Royce

Voestalpine AG's High Performance Metals Division reports that it has secured a ten-year contract with Rolls-Royce. The company has supplied Rolls-Royce for a number of years with high-quality steel alloys for engine components from its site in Kapfenberg, Austria. This new contract is with group company Voestalpine Böhler Edelstahl, marking its first entry into the market for rotating engine disks.

The Voestalpine High Performance Metals Division will supply sophisticated pre-materials for engine disks, which are required to withstand huge forces during flight. High-tech materials and special forgings from the company are already used in structural, undercarriage, wing and engine parts in all major models of aircraft, from Airbus and Boeing to Embraer and Bombardier. The group states that it currently generates revenue of around €400 million in the aerospace market, and this figure is expected to increase to €500 million over the medium term.

Voestalpine's High Performance Metals Division produces metal powders, tool steels, high-speed steels, valve steels and other products made from special steels, as well as nickel-based alloys and titanium. Böhler Edelstahl produces high-performance steels under its Microclean brand. These high-performance, high-speed and tool steels are primarily used in metal machining (hobs, end milling cutters, broaching tools, screw taps, etc) and in cold work tool applications (such as blanking and punching, fine blanking, forming, embossing), where conventionally produced materials reach their performance limits.

Additionally, hot work steels are used for pressure die casting and high-strength special steels are applied in aircraft applications, turbines in power engineering, medical engineering and in off-shore oil exploitation.

Wolfgang Eder, Chairman of the Management Board of Voestalpine AG, stated, "Over the past ten years, we have established ourselves as a leading global supplier to the aerospace industry as a consequence of our expertise in special steels. In both commercial and technological terms, the contract with Rolls-Royce is the largest breakthrough we've had in the engine segment to date and confirms the value of our consistent focus on quality and innovation."

www.voestalpine.com
www.rolls-royce.com

Carpenter Technology sees strongest quarterly operating income since 2013

Carpenter Technology Corporation, Philadelphia, Pennsylvania, USA, has announced its financial results for its fiscal fourth quarter and year ended June 30, 2019. For the quarter, the company reported net income of $48.9 million, up from $42.8 million in the same quarter 2018, while net income for the full year 2019 was reported at $167 million, down slightly from $188.5 million in 2018.

Among the fourth quarter's highlights, it was reported that Specialty Alloys Operations (SAO) had delivered a 16.3% operating margin and 20.4% adjusted operating margin. Carpenter's SAO segment manufactures premium alloys and stainless steel, and saw net sales of $532 million for the quarter (2018: $518.3 million) and $1,967.3 million for the full year 2019 (2018: $1,803.8 million).

Carpenter's Performance Engineered Products segment, the segment of the company that includes the Dynamet titanium business and the Carpenter Powder Products (CPP) business, achieved net sales for the fourth quarter of the fiscal year 2019 of $126.4 million, up from $116.3 million in the fourth quarter of fiscal year 2018. For the full year 2019, the segment reported net sales of $479.8 million, up from $429.7 million in 2018.

"The fourth quarter marked the end to a successful year as we generated our strongest quarterly operating income performance since fiscal year 2013," stated Tony Thene, Carpenter Technology's President and CEO. "Key highlights of the quarter include SAO delivering 20.4% adjusted operating margin, positive total company free cash flow of $115.8 million, and our 12th consecutive quarter of year-over-year backlog growth."

"The fourth quarter's operating income results were driven by a continued strong product mix as we generated double digit sequential and year-over-year revenue growth in the aerospace and defence end-use market given our sub-market diversity and broad platform exposure," he continued. "Also, growth in the medical end-use market remained robust as we continued to benefit from our direct customer relationships with leading OEMs and increasing demand for our high-value titanium solutions."

"Our fiscal year 2019 performance demonstrates the value of strong execution of our commercial and manufacturing strategies which drove consistent year-over-year revenue and earnings growth in the aerospace and defence and medical end-use markets. During the year, we made significant progress on obtaining the necessary aerospace qualifications for our Athens facility, We also continued to look to the future and took innovative steps to strengthen our leadership position through targeted investments in key emerging technologies."

"This past year we significantly advanced our Additive Manufacturing platform by adding powder lifecycle management solutions through the acquisition of LPW Technology Ltd," Thene added. "In addition, the expansion of our soft magnetics capabilities remains on track as we seek to capitalise on the disruptive impact of electrification across multiple end-use markets."

"Looking ahead, we are focused on advancing our solutions approach, capturing additional productivity and capacity gains through the Carpenter Operating Model, and investing in the future of our industry and our end-use markets. We believe the further execution of our strategy will enhance our long-term growth potential and drive sustainable long-term value creation for our customers and shareholders," he concluded.

www.carpentertechnology.com

Schaeffler sells Friction Products plant to management

Automotive and industrial supplier Schaeffler Technologies AG & Co. KG, headquartered in Herzogenaurach, Germany, and the management team of Schaeffler Friction Products Hamm GmbH, Hamm, Germany, have signed an agreement under which the management of Schaeffler Friction Products Hamm will take over the ownership of the company, effective immediately. The parties have agreed not to disclose the purchase price.

The management buyout has reportedly saved all 110 jobs at the Hamm location. The sale is not subject to competition regulatory approval and the transaction is expected to be completed in the near future. The resulting new company will be named Inno Friction GmbH.

Schaeffler Friction Products Hamm currently makes carrier plate-type friction linings for dry dual-clutch systems, primarily for the Schaeffler Group. At its peak, production of this part accounted for about 60% of the company's revenues, but in recent times there is said to have been a significant fall-off in demand.

Alongside friction linings, the Hamm plant supplies external customers in the industrial and automotive sectors with a range of specialised friction solutions, including applications for agriculture, lift and hoist systems, electromagnetic brakes and wind turbines. While the remaining production capacity for friction linings for dual-clutch systems at the Hamm location is expected to be phased out by 2020/21, the company's management team sees further development and growth potential in the industrial sector.

Schaeffler Friction Products Hamm GmbH (pictured) is now Inno Friction GmbH (Courtesy Schaeffler Technologies AG & Co. KG)

Matthias Zink, member of the Board of Managing Directors of Schaeffler AG and CEO Automotive OEM, stated, "The sale of the plant in Hamm is another key milestone in the implementation of our RACE efficiency program. Having explored a number of options for the location's future, we are pleased to say that the solution that has now been adopted represents the best possible outcome for all concerned."

"The new company will be able to operate in a much more agile and focused manner outside of the Schaeffler Group," he continued. "At the same time, the sale will enable us to concentrate more closely on our key growth areas of e-mobility and self-driving cars. The solution we have found for Hamm also shows that, in implementing the RACE program, we are committed to avoiding closures wherever possible and that we will do everything we can to explore all alternative options."

Dr Christian Spandern, Manager of the Hamm Plant and now Managing Director of Inno Friction GmbH, commented, "My fellow directors – Dr Vera Rührup, Frank Steinhauer and Stefan Löhr – and I are pleased at this opportunity to lead the company in Hamm into a new phase of development that will serve our employees, customers and suppliers well. The new company will continue its business relationships unchanged and will continue to work closely with the Schaeffler Group. At the same time, we see further potential to grow the Hamm location, particularly its industrial business."

www.schaeffler.de

Sagwell to showcase its superfine metal powders at global stone processing fair

Sagwell USA Inc, headquartered in Palos Verdes Estate, California, USA, has reported that it will be showcasing its superfine metal powders at Marmomac Stone fair which is taking place in Verona, Italy, from September 25–28, 2019.

The company, which was established in 2000, focuses on the research and production of micron and nanoscale metal powder by following ISO 9001 standard. Sagwell produces a range of superfine metal materials, including micron superfine pure iron powder, micron superfine pre-alloyed powder, micron copper powder and nano-sized lithium iron phosphate.

Marmomac, organised by Veronafiere S.p.A., is an international trade fair for the natural stone industry and represents the entire supply chain, from raw material to semi-finished and finished products, from processing machinery and technologies to applications of stone in architecture and design. Marmomac 2018 welcomed 68,000 visitors from 150 countries and over 1,600 exhibitors from fifty-five countries.

www.sagwellusa.com

voestalpine sees impact of economic slowdown and rising material costs

voestalpine Group, headquartered in Linz, Austria, has reported its results for the first quarter of its fiscal year 2019/2020. The group stated that the "macroeconomic environment has clouded over significantly since the start of the business year 2019/20," due to international trade conflicts and the associated, growing weakness of the global economy, which strongly affects Europe's export-oriented industries, and the automotive industry in particular.

The company reported €3.3 billion revenue for Q1 2019/20, down 3.8% from the previous year (€3.5 billion). Net profit was reported at €90 million, down from €226 million in 2018. In addition to the cooling economy and trade conflicts, a price increase in iron ore and CO_2 emission certificates were cited as the main factors.

However, the company stated that thanks to its broad product portfolio it had succeeded, despite these challenges, in generating positive demand throughout key customer segments such as rail technology, aerospace, warehouse and welding technology. In addition, it stated that it was already working on counter-acting market pressures through cost and efficiency improvement programmes across the group.

All four of the group's divisions were said to have seen a slight decline in revenue, resulting mainly from declining delivery volumes. The start-up costs at the group's automotive plant in Cartersville, USA, were also said to have resulted in downward pressure on earnings in the reporting period.

Herbert Eibensteiner, Chairman of the Management Board of voestalpine AG, stated, "The Management Board of voestalpine AG continues to work in a difficult environment, particularly with respect to the development of ore and steel prices, on achieving EBITDA for the current business year that is comparable to that of the previous business year even though the uncertainties have mounted since the start of the current business year."

voestalpine manufactures a wide range of metal powders (Courtesy voestalpine)

www.voestalpine.com

University of Birmingham pilot facility for reclaiming rare earth magnets

The University of Birmingham, UK, has been awarded €4 million to set up a pilot facility to reclaim rare earth metals from scrap as part of the EU-funded Horizon 2020 project SUSMAGPRO (Sustainable Recovery, Reprocessing and Reuse of Rare-Earth Magnets in a Circular Economy). The facility will focus on recycling magnets made of neodymium, boron and iron, which are found in hard disk drives, household appliances, electric vehicles and wind turbine generators, and are increasingly important in the transition to a green, low carbon economy.

In the last thirty years, the use of rare earth magnets has increased exponentially and demand is expected to rise to the tens of thousands of tonnes by 2030. China currently produces around 90% of the world's rare earth metals, and currently less than 1% are recycled. Additionally, there has been significant volatility in the price of rare earth metals in recent years; recycling the magnets is expected to help protect the supply chain for Europe's manufacturing base.

The grant aims to fund the development of a complete European supply chain capable of producing 20 tonnes of recycled magnets a year that would otherwise go to landfill. A robotic sorting line will locate and concentrate the rare earth magnets from scrap at Tyseley Energy Park in Birmingham, recycling facilities will extract the metal alloy powders, and these will be used to manufacture magnets in plants in the UK, Germany and Slovenia.

The process for extracting the materials was reportedly developed by a team of researchers at the University of Birmingham. Previous methods of extracting rare earth metals required disassembly and removal of the magnet; the new process uses hydrogen to break down magnetic metal alloys into a powder, which is then easily separated from the remaining components, thereby saving time, labour and money. The approach is said to also allow the recycling unit to process multiple items at the same time.

Professor Allan Walton, from the School of Metallurgy and Materials at the University of Birmingham, one of the inventors of the process, stated, "Rare earth magnets are used in practically every application that uses electricity to produce motion, and underpin industries that are worth more than £1 trillion worldwide. However, both the price and supply have fluctuated considerably over recent years. This means there is considerable opportunity for cost-efficient technologies, which make recycling viable in the long-term."

Recent studies are reported to have indicated that magnet recycling could emulate the stainless-steel market, where 25% of demand is met by secondary material.

www.birmingham.ac.uk

Sandvik reports high demand but fewer orders in Q2 2019

Sandvik AB, headquartered in Stockholm, Sweden, has reported its results for the second quarter of 2019. Revenues were said to have remained steady, but adjusted operating profit declined by 2%, adversely impacted by the negative earnings development in Sandvik Machining Solutions. In the period, order intake declined by 5% and the adjusted operating margin declined to 18.8%.

Björn Rosengren, President and CEO of Sandvik, stated, "In the second quarter, the level of demand was at a historically high level. Customer activity in the mining industry remained robust, while softer market activity in our early-cyclical businesses was noted toward the end of the quarter, most tangibly in the automotive and general engineering segments."

"The adjusted operating margin declined to 18.8%. I am not entirely satisfied with this level," he added. "After a long period of high focus on managing strong growth, we now further emphasise focus on efficiency measures. We will take further action in all business areas to deliver strong margins long-term. These activities will be promptly implemented and include a personnel reduction of approximately 2,000, which is on top of the 450 whom have already left during the first six months."

"Consequently, cost of about 1.2 billion SEK will impact operating profit in the second half of 2019. I expect total savings of about 1.4 billion SEK, and these should start filtering through already toward the end of this year," he stated.

Across the Sandvik Group, order intake decreased in the company's main global markets, with Asia showing a decline of 6%, Europe a decline of 10% and North America a decline of 8%. Orders in South America remained stable, while orders in Australia saw a significant increase of 57%.

Sandvik Machining Solutions saw a slight decline in its Q2 operating profit, reporting a total Q2 operating profit of SEK 2,483 million, down 11% on the same period in 2018. The operating margin declined to 23.3%, compared to 26.8% in the same period in 2018. The company stated that underabsorption of fixed costs due to lower production volumes impacted the operating margin by -2.7% points year-on-year. The operating margin was also adversely impacted by reduced profitability in the tungsten powder and blanks business as organic growth declined.

Sandvik Mining and Rock Technology saw a continued high order intake, earnings growth and margin expansion and further expanded its digital offering. The division saw an operating profit improve by 13%, amounting to SEK 2,115 million (Q2 2018: 1,865). Organic growth was flat at 0%, with revenues improving organically by 3% year-on-year. In total, orders for equipment remained at a high level, positively impacted primarily by the mechanical cutting and automation divisions, while orders for underground mining equipment declined.

Sandvik Materials Technology saw a decline in organic orders of 20% year-on-year. Excluding the impact of large orders, the decline was reported to be 17% year-on-year. Operating profit excluding the effects of metal prices was SEK 454 million (Q2 2018: 338 million), implying an underlying margin of 11.3% (Q2 2018: 8.7%). Adjusted operating profit increased by 9% and the adjusted operating margin improved to 14.6%. It was announced that the internal separation of Sandvik Materials Technology has now been initiated.

For the first six months of 2019, demand for Sandvik's products was said to have remained stable year-on-year. Excluding the impact from large orders, the growth amounted to -1%. Revenues increased by 1%. Demand for Sandvik's products declined at a low to mid-single-digit rate in all three major regions.

The six month order intake was SEK 53,905 million (2018: 52,620 million) and revenues were SEK 51,492 million (2018: 49,822 million), implying a book-to-bill ratio of 105%. Adjusted operating profit increased by 2% year-on-year to SEK 9,535 million (2018: 9,338 million) and the adjusted operating margin was 18.5% (2018: 18.7%), positively impacted in the amount of SEK 954 million due to changed exchange rates.

www.home.sandvik.com

Sumitomo expands cutting tool operations in Japan and Vietnam

A selection of cutting tools produced by Sumitomo Electric (Courtesy Sumitomo Electric Industries, Ltd.)

Sumitomo Electric Hardmetal Corp., a division of Sumitomo Electric Industries, Ltd., headquartered in Osaka, Japan, has expanded its cutting tool operations with the establishment of a representative office in Hanoi, Vietnam, and a logistics base for cutting tools in Kashiwa City, Japan. The company's Hanoi office will carry out marketing and other activities for its hard metal cutting tool business in Vietnam, while its new Japanese logistics base is expected to shorten delivery times for customers in east Japan.

The establishment of a representative office in Hanoi follows steady economic growth in Vietnam, with an increasing number of Japanese automakers and parts manufacturers having opened plants in the country as global production bases, as well as accelerating the installation and expansion of Vietnamese production lines in recent years.

In addition to these activities by Japanese manufacturers, a rise in machining in local industries is also generating a rising demand for cutting tools. Sumitomo Electric will provide its local sales agents in Hanoi with technical support in machining, mainly in the automotive, steel, industrial machinery, aircraft, semiconductor and precision parts industries.

The company's new logistics centre in Kashiwa City, meanwhile, is its second domestic logistics base for cutting tools, after the Kansai Logistics Center in Osaka City. According to Sumitomo Electric, the establishment of the Kashiwa centre will make it possible for orders placed in the afternoon to be delivered the next morning to companies in the Tohoku and Kanto region, as well as further west.

www.global-sei.com

China shifts automotive strategy to lighten controls on fuel-efficient hybrids

Electric vehicle makers in China, such as Polestar, are expected to benefit from the new policy (Courtesy Polestar)

The Chinese government's Ministry of Industry and Information Technology, which oversees automotive policy, is reported to have plans to amend its automotive strategy to lighten controls on fuel-efficient hybrid vehicles compared with gasoline or diesel vehicles, according to *Nikkei Asian Review*. Under current regulations, hybrid vehicles are grouped with conventional gasoline vehicles. If the amendment goes ahead, they would still be considered fossil-fuel-powered but reclassified as 'low-fuel-consumption passenger vehicles.'

Automakers are currently required to produce 20,000 high-performance electric vehicles for every one million hybrids they produce, under a point-based quota system. Under the newly-proposed regulations, automakers would need to produce only 6,000 electric vehicles per million hybrids, while the requirement for gasoline vehicles would rise to 29,000 for every one million gasoline vehicles.

The new development is expected to be especially beneficial for Japanese automakers Toyota Motor and Honda Motor, who together sold more than two million hybrids worldwide in 2018, accounting for the vast majority of the 2.29 million produced that year, according to IHS Markit. Hybrid sales are said to have accounted for just over 10% of the nearly 1.49 million vehicles sold in China by Toyota in 2018; the automaker now aims to boost this to above 30% by 2020.

The proposed amendments to the regulations also includes measures to promote hydrogen fuel cell vehicles. Toyota has recently been partnering with a number of Chinese companies, including Beijing Automotive Group, in the development of such vehicles.

Further, the proposed amendments would allow automakers that beat the quota in one year carry over points to the following year under certain conditions. The government plans to continue increasing the quota, which will rise to 12% in 2020 and by two percentage points each year between 2021 and 2023.

Yoshinobu Takeda receives the 2019 Ulf Engström Award

This year's Ulf Engström Award has been presented to Yoshinobu Takeda, Technical Support Engineer at Höganäs in Japan. The annual award is given to an employee of Höganäs who is said to have laid ground for a commercially successful development of the PM industry. The jury cited Yoshinibu's "life long devotion to and development of PM technology" in their motivation.

The award was presented to Takeda during a ceremony at Höganäs' tech centre in Shanghai, China. "I'm very surprised to have such an honourable award and I am happy to be seen as a person who contributed to Höganäs," stated Takeda.

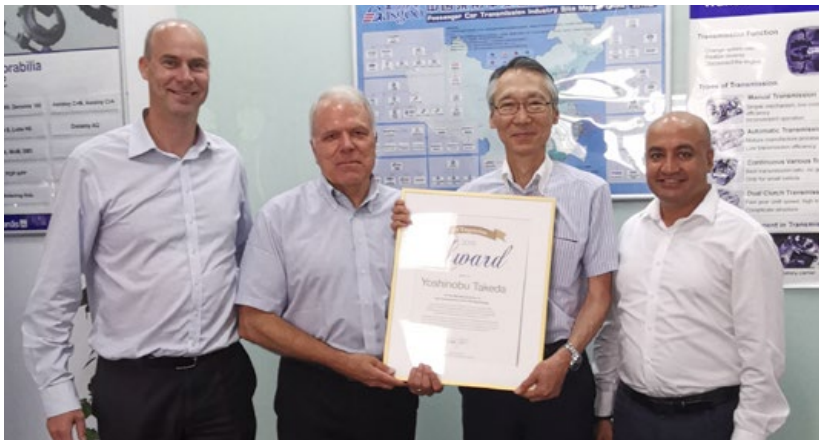
"Reviewing my eighteen years in Höganäs, this award brings not only a feeling of surprise or happiness; it is much more than that. I recognise that I am a lucky person, and have been given many excellent opportunities. I hope the award will inspire colleagues to work hard for more business opportunities for Höganäs and expand the market, not only for Höganäs, but for PM as a technology."

During his career, Takeda has contributed to building Höganäs' technical support function in Japan, participated in several global development projects and developed the company's local Metallography schools.

"I have known Takeda-san for more than thirty years and think he really deserves this award for his outstanding support to the PM industry, not only in Japan but worldwide," added Ulf Engström.

Carl Eklund, who heads up the Höganäs team in Japan, presented the award to Takeda. "What is most remarkable about Takeda-san is that he is always willing to learn and explore new technologies. As of late, he has shown a keen interest to promote 3D printing. He is a true believer in the many opportunities for metal powders, promoting them as smart solutions and sustainable technology. He is a true role model, Mr PM."

www.hoganas.com



From left to right: Mark Braithwaite, President Continent APAC, Carl Eklund, President Höganäs Japan, Yoshinobu Takeda, Technical Support Engineer at Höganäs Japan, Shashi Shukla, President Product Area Electro & Mechanical Technologies (Courtesy Höganäs)

ZF's WABCO acquisition to go ahead with shareholder approval

The shareholders of WABCO Holdings, headquartered in Bern, Switzerland, a global supplier of braking control systems, technologies and services for the safety, efficiency and connectivity of commercial vehicles including trucks, buses and trailers, have approved the company's acquisition by ZF Friedrichshafen AG, Friedrichshafen, Germany, a global technology company and systems supplier for passenger cars, commercial vehicles and industrial technology.

The planned acquisition was first announced in March 2019, with ZF and WABCO stating that they would form a leading global integrated mobility systems provider for commercial vehicles, creating added value for ZF's commercial vehicle customers. The combined company is expected to have annual sales of approximately €40 billion.

At a meeting of WABCO's shareholders in New York, USA, holders representing 68.44% of the company's shares voted in favour of adopting the proposed merger agreement. Overall, 71.97% of WABCO's shareholders were said to have participated in the vote. Under the agreement, ZF will acquire all outstanding shares of WABCO for $136.50 per share in an all-cash transaction for an equity value of over $7 billion.

Jacques Esculier, Chairman and CEO of WABCO, stated, "We are very pleased that WABCO's shareholders have supported our merger plans recognising that the ZF transaction offers a compelling strategic fit to advance the requirements of our industry, while also providing certainty of value and liquidity for our shareholders."

The proposed merger remains subject to further customary closing conditions and regulatory approvals. ZF and WABCO stated that they expect the transaction to close in early 2020.

www.zf.com
www.wabco-auto.com

寒锐钴业
HANRUI COBALT

Our Cobalt Powder

Your Best Solution for

Costs Cutting and

Performance Improving

Email: info@hrcobalt.com
Visit us: www.hrcobalt.com

NANJING HANRUI COBALT CO., LTD.

Recruiting for a Global Sales Manager, contact us: rt@hrcobalt.com

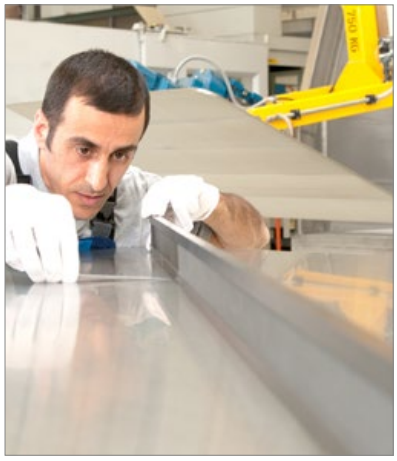
Plansee's latest sputtering targets feature at Taiwanese international display manufacturing event

Plansee showcased its latest sputtering targets for flat screens, touch screens and smart glasses at the Touch Taiwan 2019 – Display International exhibition, which took place at the Taipei Nangang Exhibition Center in Taipei, Taiwan, August 28–30, 2019.

Plansee's coating materials are used in a range of applications, including ultra-high definition screens and touch panels, as well as components for LEDs, solar cells and batteries. The coating materials also need to be ultra-pure, which is why Plansee supplies molybdenum targets at a guaranteed purity of 99.97%. The benefits of this are a high level of conductivity and time savings due to excellent sputtering rates. According to Plansee, it can specifically influence the microstructure of the coating material through the powder metallurgical production process, which provides uniform sputtering rates and homogeneous layers.

"We deliver sputtering targets in all common sizes. Depending on your coating system, we supply rotary and planar targets," stated Harald Selb, Business Segment Manager Thin Film. "From the powder to the local bonding of the targets in one of our Asian Plansee bonding shops – Plansee performs every stage of the production process in-house. Our service is distinguished by a close cooperation with our customers and the development of individual solutions," he added.

www.touchtaiwan.com
www.plansee.com



Thanks to its good adherence to glass and a high level of electrical conductivity, molybdenum is a popular material for electrode layers in thin-film transistors (TFT-LCD) and touch screens (Courtesy Plansee)

Liberty Powder Metals orders new ASL atomiser for highly spherical free-flowing powder production

Atomising Systems Ltd. (ASL), Sheffield, UK, has been awarded a contract for the turnkey installation of a 250 kg Vacuum Inert Gas Atomiser at Liberty Powder Metals Ltd, a subsidiary of Liberty House Group, also located in Sheffield.

Working in cooperation with Consarc Engineering, a supplier of vacuum melting technology, ASL has equipped the atomiser with its proprietary anti-satellite and hot gas atomisation systems.

"The Anti-Satellite technology is a game changer in terms of powder shape and flow properties. Coupled to a vacuum melting furnace from a renowned specialist like Consarc, Liberty will be set to supply their clients with powder of the highest quality," stated Dr Paul Rose, ASL Commercial Director.

The high-specification atomiser will enable Liberty to produce highly spherical, extremely free flowing, special steel-based and non-ferrous alloy powders for their demanding aerospace clients to use in Additive Manufacturing, as well as HIP and MIM applications.

www.libertyhousegroup.com | www.consarceng.com
www.atomising.co.uk

Horizon Technology outlines design considerations for PM tooling

Horizon Technology, St. Mary's, Pennsylvania, USA, has outlined its design guidelines for Powder Metallurgy tooling on its blog. The guide, titled 'Design Considerations for Powder Metallurgy: Tooling Do's & Don'ts', describes the impact which tooling design choices can have on the entire manufacturing process, and what steps to take and to avoid to ensure a positive outcome.

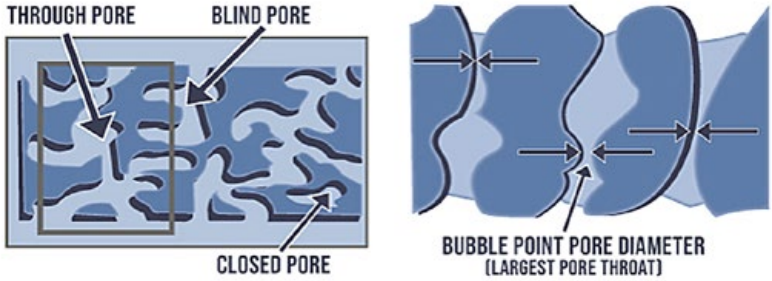
Factors taken into consideration for the design of tooling for PM include:

- Net metal shaping
- Compaction ratios
- Cost efficiency
- Powder metal part wall thickness
- All-in-one manufacturing capabilities
- New & innovative metal powders
- Tooling lifetime

Each design consideration is considered in great depth, with a focus on maintaining low part and process costs and high tool lifespan. While there are further, more complex issues which must be considered, the six dos and don'ts covered by Horizon Technology are expected to offer a solid base for the design of good quality tooling.

www.horizontechnology.biz

Particle Testing Authority expands its pore analysis capabilities



CFP and LLDP are used to measure pores (Courtesy Particle Testing Authority)

Particle Testing Authority (PTA), a division of Micromeritics Instrument Corporation, headquartered in Norcross, Georgia, USA, reports that it has expanded its pore analysis capabilities by implementing Capillary Flow Porometery (CFP) and Liquid-Liquid Displacement Porometry (LLDP).

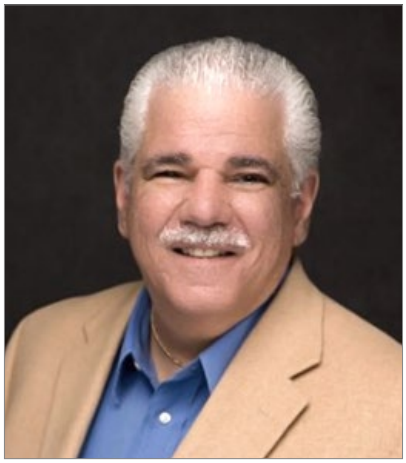
The company states that by using CFP, pore properties are calculated by measuring the fluid flow when an inert, pressurised gas is applied to displace an inert and nontoxic wetting fluid impregnated in the porous network of the samples with pore sizes of 500 to 0.015 microns. Parameters such as first bubble point (corresponding to the largest pores present) can be calculated with accuracy and repeatability according to ASTM F-316.

The company explains that LLDP can measure nanopores (1,000 to 2 nm) at low pressures by displacing the wetting liquid with an immiscible liquid at increasing pressure. This reportedly eliminates error from collapse or mechanical damage caused by high pressure when measuring materials such as hollow fibres. With these recently implemented methods, the company can analyse materials such as textiles (woven and non-woven), paper, polymers, metals, ceramics, and porous rocks to understand how high a throughput can be achieved.

"We currently measure porosity and pore size using gas adsorption techniques and mercury porosimetry, so CFP and LLDP allow us to help more customers address their material characterisation questions and problems," stated Greg Thiele, PTA's, General Manager. "We have performed various analyses for our customers in the energy storage industry, and CFP has allowed us to provide a more comprehensive characterisation for battery separators."

www.particletesting.com

Shortfall in experienced PM staff limiting further industry growth, claims new PM consultancy



Dr Michael Krehl (left) and Rocco Petrilli (right) have formed the new PKPM Advisory Group to support the growth of PM companies

According to Dr Michael Krehl, Co-founder and Partner at the PKPM Advisory Group, the Powder Metallurgy industry is experiencing a period of record output that has helped most forget the 2008-9 global crisis. The recent growth has restored technology development, along with the once ever-present industry expansion which began in the 1980s. During this time of growth, however, new weaknesses have been exposed which hamper PM companies from maximising their profitability in a time of fixed cost over absorption.

"The continued absence of a formal academic source for PM professionals, coupled with baby boomer expert retirements and a departure of the millennial generation from the traditional manufacturing sector, has created an unparalleled talent shortage in the PM industry," added Krehl. "Employment ads and job fairs in traditional PM strongholds have proven ineffective, and traditional headcount budget control, once the primary challenge of PM company leadership, became a contrary challenge as headcounts ran 15-20% under budgeted levels due to talent shortages."

"These deficiencies have resulted in premium labour costs, and other increased operational overheads, which will have prevented those companies achieving higher profits," added Rocco Petrilli, Co-founder and Partner at PKPM Advisory Group. "Additionally, even deeper talent shortages in the skilled and technical ranks, have resulted in extended equipment issues due to incomplete maintenance on over-stressed manufacturing equipment and unsolved engineering problems."

In a time where global automotive demand has peaked, and trade wars and tariffs add to the uncertainty of this cyclical nonsymmetrical pattern, the PM industry can no longer rely on volume to ensure financial results in the black. "Increasing this challenge are new and uncharted technological advancements in vehicle electrification that increasingly challenge the traditional powertrain powder consuming components, making future PM development efforts increasingly vital," added Petrilli. "And all this at a time when technical ranks are depleted and general know-how is at critically low levels."

This shortage of talent is not unique to the PM industry. In fact, such issues exist in many markets, including most manufacturing sectors. To bridge these gaps, many companies employ consultants or specialists to drive technical, commercial and talent solutions to these pending problems. "The availability of such subject matter experts in PM is, however, limited during this time of significant need," stated Krehl. Recognising this demand is what led to the formation of the PKPM Advisory Group, where Krehl and Petrilli have, for the third time in their careers, combined their talents.

In 2003, Petrilli joined Krehl to establish the initial North American presence for Sinterstahl GmbH, on their way to the creation of one of the first global footprints in the PM industry. This partnership stemmed from an earlier association, in which Petrilli and Krehl formed a supply partnership to answer Borg Warner's emerging engine timing system sprockets in Europe.

"Dr Krehl and I have a twenty-three year professional and personal friendship built on confidence, trust and a common attraction to solving big problems," stated Petrilli. "We are excited to join again and bring these skills to an industry that we value and appreciate for the opportunities that it provided to both of us in our successful careers."

PKPM will provide strategy development/execution, manufacturing, sales marketing and business development, R&D and talent acquisition and retention. Further advisory services, involving mergers and acquisitions, include valuation of acquisition targets, planning and execution of due diligence processes and integration of newly-acquired enterprises.

"Success in a Powder Metallurgy business is so much about the people and the know-how" added Krehl. "PKPM will apply its unmatched combined expertise to create swift and effective problem solutions to its global clients' most challenging needs. Rocco and I have successfully faced some of the most trying circumstances in our time together and now look forward to delivering the same quality results to a growing global PM client base."

www.pkpm-advisory.com

Sumitomo develops new coated carbide grade for exotic alloy turning

Exotic alloys such as nickel (Ni)-based alloys, cobalt (Co)-based alloys, and titanium (Ti) alloys are often used for equipment and parts used in the aircraft and auto industries, due to their superior heat resistance and corrosion resistance. As reported in Sumitomo Electric Industries' *SEI Technical Review*, No. 88, April 2019, there has been a growing demand for tools for machining these alloys.

When cutting exotic alloys, the work material is likely to adhere to the cutting edge of a tool, which can result in its sudden fracture, states the report. The tool life is therefore significantly shorter than that of tools for cutting general steel.

To meet the demand for cutting tools with stable performance and extended tool life, SEI has developed AC5015S and AC5025S coated carbide grades. These are characterised by improved wear resistance and fracture resistance, the result of applying a newly developed physical vapour deposition (PVD) coating and a unique cemented carbide.

Cutting tools used for the turning of exotic alloys need to meet the requirements of oxidative wear resistance and diffusional wear resistance, the report explains. Absotech, SEI's proprietary PVD coating technology, and a newly developed AlTiSiN-based film, are said to have improved oxidation resistance and reaction resistance, resulting in twice the wear resistance compared to conventional products.

The report went on to state that cutting tools for the turning of exotic alloys also need to meet the requirement of notch wear resistance and fracture resistance. The use of newly developed raw materials and a new sintering process are said to have significantly improved toughness, while maintaining hardness. SEI stated that this has resulted in a fracture resistance 1.5 x that of conventional products.

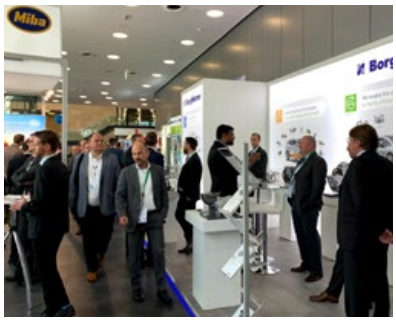
global-sei.com

SEI has developed new grades of coated carbide (Courtesy SEI)

Dritev announces 2020 event following success in Bonn

The VDI Transmission Congress 'Dritev – Drivetrain for Vehicles 2020', organised by VDI Wissenforum GmbH, will take place in Bonn, Germany, June 24–25, 2020. Following a successful event held at the World Conference Centre in Bonn this year, the congress is set to return to the same venue and will again showcase the latest developments in the automotive drivetrain industry.

Dritev 2019 attracted over 1,300 delegates, with around 100 exhibitors. Sessions on the conference programme covered current drivetrain technology as well as solutions for electrical powertrains, hybrid systems, increasing power density and transmission concepts.



Over 100 companies exhibited at Dritev 2019

In addition to acting as a media sponsor, *Powder Metallurgy Review* exhibited at this year's event. From our booth and the media distribution point, copies of *PM Review*, *Metal AM* and *PIM International* were available for all visitors. Believed to be one of the largest networking platforms for automotive powertrain and transmission development, Dritev proved an ideal opportunity to reach a focused end-user market.

www.vdi-wissensforum.de

MPP announces Lunsford as CFO

MPP, a Mill Point Capital portfolio company based in Noblesville, Indiana, USA, has announced the appointment of Tom Lunsford as its Chief Financial Officer. Lunsford is reported to bring over twenty years of experience to the position and will be responsible for development and execution of the financial strategy supporting MPP's business plan.

MPP is a global provider of PM and MIM solutions, it produces various components such as custom-engineered gears and sprockets, complex structural parts, high-strength aluminium parts and components requiring unique mechanical and physical properties.

The company operates nine production facilities in the US and China.

www.MPPinnovation.com

ALD's new Velocity Gauge enables gas flow measurement during quenching

ALD Vacuum Technologies GmbH, a division of AMG Advanced Metallurgical Group N.V., headquartered in Hanau, Germany, reports that its newly developed Velocity Gauge enables the gas flow in the batch chamber to be checked during gas quenching, helping to ensure the quality of gas-quenched components.

According to the company, an important process parameter in gas quenching is the flow velocity of the circulated quenching gas, as well as other parameters like quenching pressure, gas type and temperature, that determine the quenching intensity. These parameters can significantly influence the achievable component properties such as hardness, microstructure and distortion.

ALD states that it is important to ensure that these process parameters are measured and documented. Although gas temperature and gas pressure are reportedly recorded and documented by appropriate sensors, the gas velocity is generally not recorded.

The measurement can be recorded by a Velocity Gauge which works according to the physical measuring principle of a Prandtl sensor. The company explains that this makes it possible to measure the distribution of the flow velocity over the base area of a quenching chamber without great effort.

Once the measurement has been recorded, a protocol with the current measurement data is generated which can then be compared with the data at the time of delivery of the quenching system. In case of deviations, the analysis of the measured flow profile enables conclusions to be drawn about possible causes of faults in the system.

www.ald-vt.com

Insertion of a Velocity Gauge into the quenching chamber of a SyncroTherm (Courtesy ALD Vacuum Technologies)

Euro PM2019 Special Interest Seminars focus on key areas of Powder Metallurgy

The EPMA's Euro PM Congress & Exhibition 2019 is set to take place at the Maastricht Exhibition Congress Centre (MECC) in Maastricht, the Netherlands, October 13–16, 2019. During the four-day event, delegates will have the opportunity to choose from seven parallel conference strands covering different aspects, technologies and sectors of the Powder Metallurgy industry.

The opening session on October 13 will provide an 'Overview of the graphite industry from the PM perspective,' presented by Asbury Graphite & Carbons, as well as a presentation on 'Powder based laser processes in the context of digital photonic production and industry 4.0' by Prof Johannes Schleifenbaum, Chair of Digital Additive Production, RWTH Aachen, Germany.

After the opening sessions, a special panel session will run titled '60 years of EPMA: From 30 years ago to the next 30 years', which is expected to represent all of the different PM sectors and will be facilitated by Dr Cesar Molins, AMES SA, Spain, as part of the EPMA's 30th anniversary celebrations.

In addition to the three days of technical sessions at Euro PM2019, Special Interest Seminars (SIS) will focus on specific areas of the PM industry in more depth. The seminars will cover the following topics:

- The evolution of press and sinter linked to the 30th anniversary of EPMA
- The development of press and sinter within the automotive sector
- Porosity from past to future: A defect to avoid becomes an added value
- Porosity from past to future: Applications and case studies
- The future of HIP
- Optimising the properties of AM parts using Hot Isostatic Pressing
- Nano, near-nano and ultrafine hardmetals
- MIM and AM
- The future of MIM
- 30 years of EPMA: Looking back and into the future of AM
- Industrialisation of AM

www.europm2019.com

Submitting news...

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

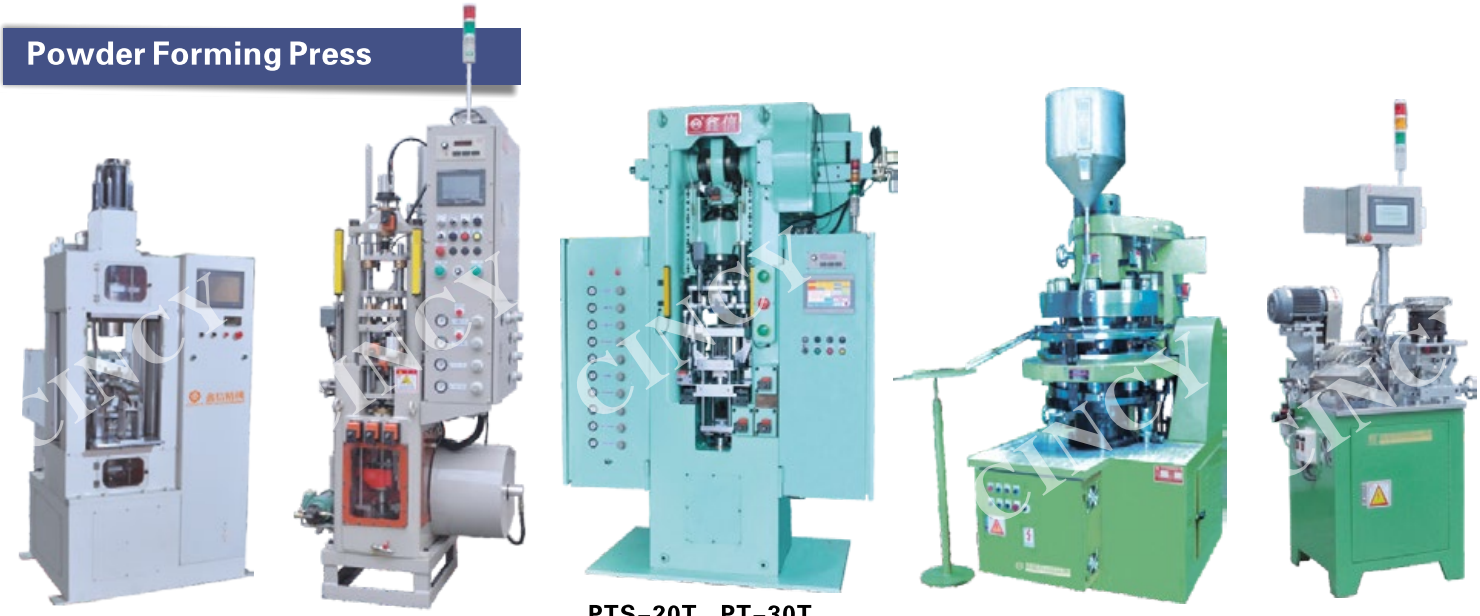
CINCY(China)Mould Machinery Co., Ltd. Mainly Products:

CINCY 鑫信精機 CINCY PRECISION MACHINERY

(1) Powder metallurgy mould ;
(2) Magnetic materials mould;
(3) Precision ceramic mould;
(4) Carbon brush、pharmaceutical mould;
(5) Inductors integrally molding mould;
(6) Metal or ceramic injection mould (MIM、CIM);
(7) Precision plastic or die casting mould;
(8) Cold forging mould;
(9) CNC powder molding press;
(10) Rotary type powder molding press;
(11) Upright type powder molding press;
(12) DR、square machining machine;
(13) Automation equipment;
(14)Fixtures, jigs, gauges;
(15) Diamond grinding wheel、alloy core cutter blade (NR series);
(16) Superhard alloys materials parts manufacture;
(17) Auto parts and other precision parts processing.

Powder Metallurgy Mould

Powder Forming Press



CC-CNC-5T~100T Servo Press Series

PB-3T、PB-6T Powder Forming Press

PTS-20T、PT-30T PT-40T、 PT-60T Powder Forming Press

Rotary Type Powder Forming Press

Multi-function Processing Machine

GUANGDONG CINCY (CHINA) INDUSTRY CO.,LTD.
POWDER METALLURGY MOULD AND MACHINERY

Head Office Add: Cincy Industry Area, Hengdong Road, Fengda Village, Dongkeng Town, 523448, Dongguan City, China.

Tel: +86-769-85447747 (Ext.888)
Fax: +86-769-85331932
Mobile: +86-13549366908 Mr Wilson
E-mail: cincy@cincy.com.cn
Website: http://www.cincy.com.cn

Remembering Dr Bob Moon

John Robert (Bob) Moon, PhD C Eng CPhys FInstP FIMMM, a well-respected Powder Metallurgy industry expert, passed away earlier this year. Born in Cardiff, Wales, UK, in 1936, he received his BSc and PhD in physics from the University of Wales and began his career in the South Wales steel industry. He subsequently moved to the Birmingham, UK, area where he worked on advanced titanium and zirconium alloys at Imperial Metals Industries. His final industrial position was at CA Parsons, Newcastle-upon-Tyne, UK, covering the design and construction of large steam turbines.

He was a member of the academic staff at the University of Nottingham from 1967–2008, acting for periods as Director of Studies in the school of Mechanical, Materials, Manufacturing Engineering and Management, and as Vice Dean of the Faculty of Engineering. While his research interests encompassed a variety of topics, Powder Metallurgy was predominant in recent times and he had more than fifty published papers on PM and related topics.

Moon had close ties to the PM community in Eastern Europe. He was a regular speaker and attendee at the International Conference on Deformation and Fracture in Structural PM Materials held at Stará Lesná in the Slovak Republic, as well as the RoPM congresses held at various locations in Romania. He was instrumental in the establishment of the European Powder Metallurgy Association (EPMA)'s PM Summer School and, from 1998–2008, was its scientific leader and coordinator. He continued to teach at the Summer School through 2018, conducting popular sessions on the Analysis of Problems related to PM.

While at Nottingham University, he helped develop equipment for the 'skeleton' bobsled discipline and visited the United States to attend the Winter Olympics in Salt Lake City, Utah, USA, to support the UK team.

Our thanks to W Brian James, Bob's friend and colleague, for his significant contribution to this obituary.

Dr Bob Moon (right) at the EPMA's PM Summer School with Joan Hallward (centre) and Karen Powell (left) (Courtesy EPMA)

GKN Powder Metallurgy completes hydrogen storage-based home

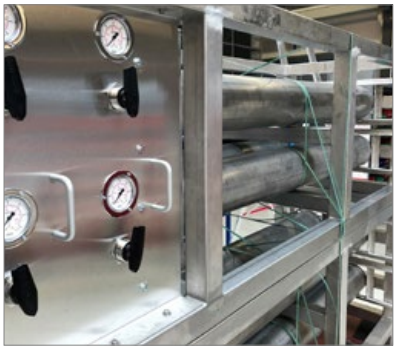
GKN Powder Metallurgy has opened the doors to a self-sustaining residential home located in the South Tyrolean Alps. The building, which has no access to a public power grid, now operates a CO_2-free energy supply system, storing locally generated power from renewable sources in GKN's Hy2Green energy storage system. The energy storage system uses metal powder to safely and compactly hold hydrogen as its energy source, which is then used to provide electrical power and heat to the home when needed, with no emissions other than water and oxygen.

GKN Powder Metallurgy announced plans to develop an innovative hydrogen storage system for residential homes using solid state metal hydride in August 2017. In the Hy2Green process, hydrogen is generated in an electrolyser unit powered by a regenerative energy source and fed into storage tanks filled with metal powder. The hydrogen bonds to the metal particles to form metal hydride and, through temperature adjustments, the hydrogen is released to a fuel cell. The energy is then converted to electrical power.

According to GKN, the metal powder-based Hy2Green system needs twenty times less space for the same amount of energy at the same pressure rate compared to gaseous hydrogen storage systems. The system works at the safe pressure rate of only thirty bars, while storage systems for gaseous hydrogen run at pressures of up to 800 bars.

Peter Oberparleiter, CEO GKN Powder Metallurgy, stated at the house's opening, "A dividing factor against other systems is our use of iron metal and titanium, which is available in vast amounts compared to lithium being used for modern researchable battery storages. The life expectancy of our metal-hydride based Hy2Green storage lays at approximately ten years, as opposed to the three-year lifespan for an electric battery storage."

www.gknpm.com



GKN Powder Metallurgy's storage module can store 133 kWh electric power (Courtesy GKN)

Volume Graphics releases new CT software solutions for non-destructive testing

Volume Graphics GmbH, headquartered in Heidelberg, Germany, has released version 3.3 of its software solutions for non-destructive quality assurance with industrial computed tomography (CT): VGStudio Max, VGSTudio, VGMetrology, and VGIn-Line. Volume Graphics' VGStudio Max software is used for the analysis and visualisation of industrial CT data and is said to cover all requirements related to metrology, defect detection and assessment, material properties, and simulation.

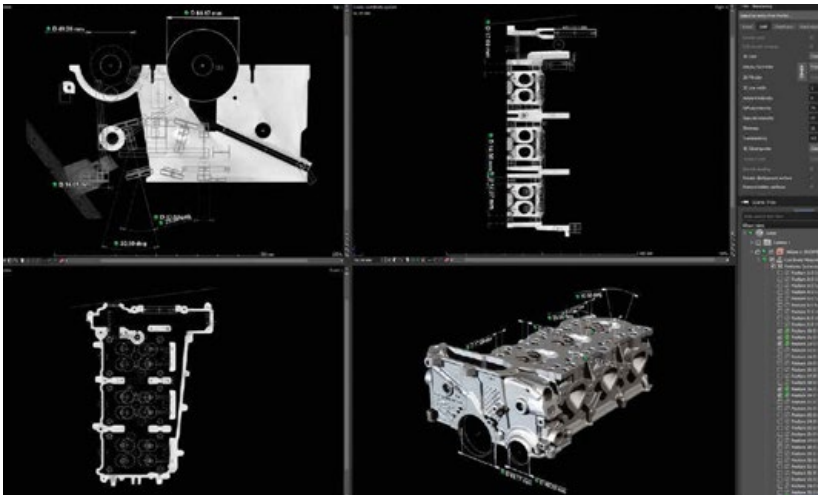
Using the new version, customers can reportedly determine the surfaces of multi-material components, export measurement and analysis results to store them centrally in quality-management software, automate inspection processes more flexibly based on text recognition, and translate real CT data into volume meshes for simulation. To further support its customers, Volume Graphics has also added a new Technical Consulting unit that provides professional consulting and evaluation services.

"With version 3.3 of our software solutions, we are once again laying the foundation for customers to make their processes smarter," stated Christof Reinhart, CEO and co-founder of Volume Graphics GmbH. "For example, using the new data export, metrology data derived with the tremendous measurement capabilities of our software can be seamlessly shared with QA systems, where the values can then be combined and checked over time."

"More than ever before, this new feature enables customers to better integrate leading-edge CT technology into their existing software landscape," he continued. "The new export feature is based on the native support of the widely used Q-DAS format, which makes using results in third-party statistical or analysis software especially easy."

Volume Graphics GmbH has been developing software for non-destructive testing based on industrial CT for over twenty years, and is said to have a market share of around 80%. Its software is used widely for quality assurance in product development and production by customers in the automotive, aerospace, and electronics industries.

www.volumegraphics.com



Volume Graphics' VGStudio Max software for CT inspection (Courtesy Volume Graphics)

Dansk Sintermetal to showcase PM components at manufacturing subcontractor exhibition

Dansk Sintermetal A/S, headquartered in Haderslev, Denmark, is set to showcase its range of PM components at Elmia Subcontractor 2019, said to be Northern Europe's leading subcontracting trade show which will take place in Jönköping, Sweden, from November 12–15, 2019.

Dansk Sintermetal can manufacture PM components from 0.3 g to 3 kg, and states that it has the flexibility for volumes ranging from 5,000 up to 100,000 parts per year or more. The company offers components in iron, steel, stainless steel and various copper based alloys.

Elmia Subcontractor 2019 is a four-day event organised by Elmia AB, headquartered in Jönköping, Sweden, and brings together the manufacturing industry's suppliers and their customers. The trade fair is expected to receive over 1,200 exhibitors from thirty countries.

Dansk Sintermetal will be located at Stand B05: 18/8 during the event.

www.elmia.se/en/subcontractor

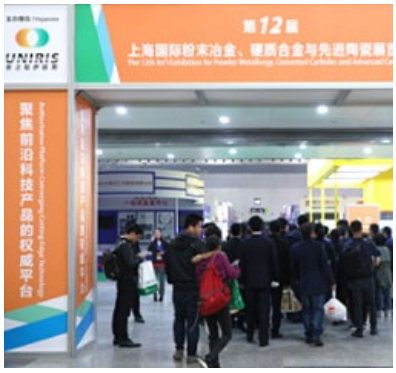
www.sintermetal.dk

Dansk Sintermetal is set to showcase a range of its PM components

PM China 2020 set for Shanghai next March

PM China 2020, the 13th Shanghai World Expo Exhibition and Conference, will once again take place at the Shanghai World Expo Exhibition & Convention Center, China, from March 24–26, 2020. The event, organised by Uniris Exhibition Shanghai Co., Ltd, will include a number of forums and meetings focused on key Powder Metallurgy topics.

The three-day event will also include 2020 PM Industry Forum & Metal Injection Molding Symposium and will be held concurrently with the 2020 International Advanced Ceramics & Cemented Carbides Exhibition & Conference. The theme of PM China 2020 is 'Convergence of Cutting-edge Technology & Products'.



The 2020 conference is expected to attract over 500 exhibitors

The 2020 conference is expected to attract approximately 30,000 visitors from more than twenty countries, and over 500 exhibitors. The organisers state that the conference has maintained an average annual growth rate of 32%. Further information and pre-registration details are available via the event's website.

en.pmexchina.com

PIM technology on show at Formnext 2019

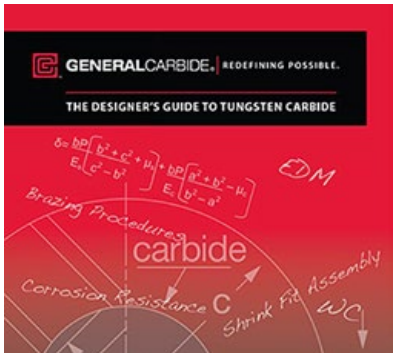
A major showcase of more than a hundred components, manufactured by Metal Injection Moulding (MIM) and Ceramic Injection Moulding (CIM), will be held at Formnext 2019, taking place in Frankfurt, Germany, November 19-22.

Organised by *PM Review's* sister publication, *PIM International* magazine, in partnership with Mesago Messe Frankfurt GmbH, the showcase will highlight the capabilities of PIM technology along with its broad range of application areas.

The showcase, located in Hall 11.0, stand A51, will feature parts from Europe, North America and Asia.

www.pim-international.com
www.formnext.com

General Carbide publishes highlights from *The Designer's Guide to Tungsten Carbide*



The Designer's Guide is available from General Carbide

General Carbide, headquartered in Greensburg, Pennsylvania, USA, a manufacturer of finished tooling, wear parts and components, has published a selection of highlights from its book *The Designer's Guide to Tungsten Carbide*.

Also referred to as cemented carbide, tungsten carbide (WC) is used in many cutting tool applications and has been developed into an engineering material used to resist the harshest environments of corrosion, high temperature, impact, high compressive loads, deformation and severe abrasion.

Cemented carbide is the preferred material for parts that must withstand all forms of wear and exhibit a high degree of toughness. It exhibits high compressive strength, resists deflection, and retains its hardness values at high temperatures, a physical property especially useful in metal-cutting applications. It provides long life in applications where other materials would not last or would fail prematurely.

Although various carbide manufacturers use different manufacturing processes, the final product is obtained by compacting the powder formulation and sintering the constituents into a solid mass in which cobalt, or a similar metal, bonds or cements the particles of carbide together. Rigorous control is necessary throughout the manufacturing process since the quality of the final product can be greatly affected by seemingly insignificant factors.

The guide, available to download in full at General Carbide's website, offers an overview of production techniques and highlights the many advantages of using tungsten carbide in numerous applications.

www.generalcarbide.com

AMES announces the winners of its Joan Antoni Bas R&D Award

AMES, Barcelona, Spain has announced the winners of AMES – Joan Antoni Bas R&D Award during a prize-giving ceremony held during the seventh Spanish Conference on Powder Metallurgy and second Ibero-American Conference on Powder Metallurgy, which took place in Madrid, Spain, on June 25, 2019.

According to AMES, it named the award after Joan Antoni Bas, said to be one of the pioneers of Powder Metallurgy in Spain. Dr Bas set up the Research Department of AMES and was its director for over thirty years. He worked in hardmetal, structural components, self-lubricated bearings and soft magnetic materials, and especially in characterising and improving basic manufacturing processes. During his career, he was a key player in the technological development of PM in Spain.

The winners of AMES' Joan Antoni Bas R&D Award, Dr Ana Ferrández (left) and Dr Lorena Lozada (right) (Courtesy AMES)

First prize was awarded to Dr Ana Ferrández, Spanish Ceramics and Glass Institute, for her work, 'Processing of Mg base materials through the combination of colloidal techniques and Additive Manufacturing.'

Second prize was awarded to Dr Lorena Lozada, Centre for Technical Research and Studies of Gipuzkoa (CEIT), for her work 'Sintering of TiCN-based cermets with multi-component metal binders for high-speed machining of treated steels and ADI castings'.

www.ames-sintering.com

Buehler appoints Opti-Tech Scientific as representative in Canada

Buehler, an ITW Company, headquartered in Lake Bluff, Illinois, USA, has formed a partnership with Opti-Tech Scientific Inc, a supplier of scientific equipment, specialising in optical / digital microscopy, metallography and hardness testing based in Pickering, Ontario, Canada. The partnership will provide Buehler's customers in Canada with local support for their metallographic product and service needs.

Opti-Tech will offer Buehler's wide range of services (Courtesy Buehler)

Under the agreement, Opti-Tech will offer Buehler's line of full metallography solutions for sample preparation, materials characterisation and hardness testing. Customers will benefit from a team of experts in the industry, local sales support, quick service response and stocked consumables warehouse located in the Toronto area for fast fulfilment. Opti-Tech's distribution centre in Toronto will ship throughout all the Canadian provinces. The company also has a sales office in Vancouver.

Benjamin Mangrich, Americas Commercial Director for Buehler, commented, "We are excited to partner with Opti-Tech, an outstanding distributor with in-depth technical knowledge, an experienced service team and impeccable standards. The Opti-Tech team is familiar with Buehler products and the unique requirements of Buehler customers. This partnership is a win-win-win for Buehler, our customers and Opti-Tech."

"We are honoured to take on the Buehler line of metallographic and Wilson hardness testing products," explained Martin Howells, Opti-Tech's President. "As a solution-based company, we promise Buehler customers uncompromising support, a dedicated sales team, knowledgeable application specialists and expert installation, training and service. Our team includes seasoned professionals in metallography and we look forward to continuing this legacy throughout Canada."

www.buehler.com
www.opti-tech.ca

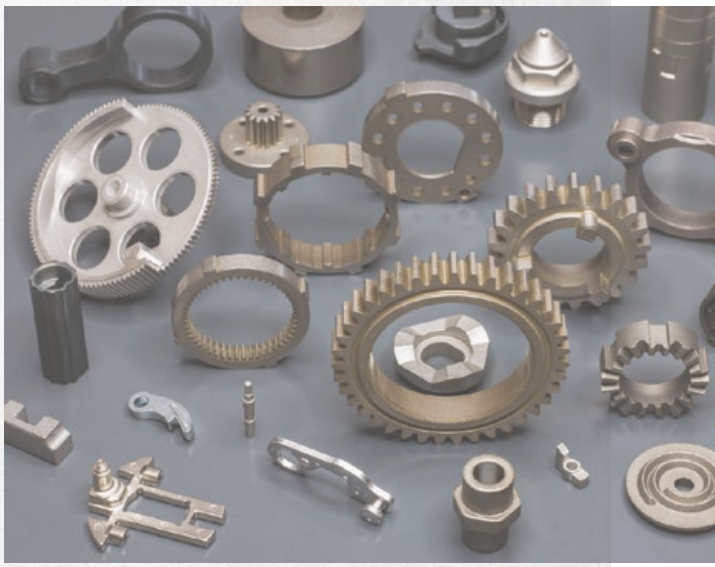
Slovak company GEVORKYAN finalizes investment in Additive Manufacturing and increases capacities in PM, MIM and HIP.

GEVORKYAN was established in Slovakia in 1996 by an Armenian immigrant. The family has a 50 year history in innovation, development and production of Powder Metallurgy components. It supplies PM and MIM parts to global customers in automotive, locks and security systems, hand tools, oil industry, agriculture, firearms, medical, cosmetics and many other industrial products.

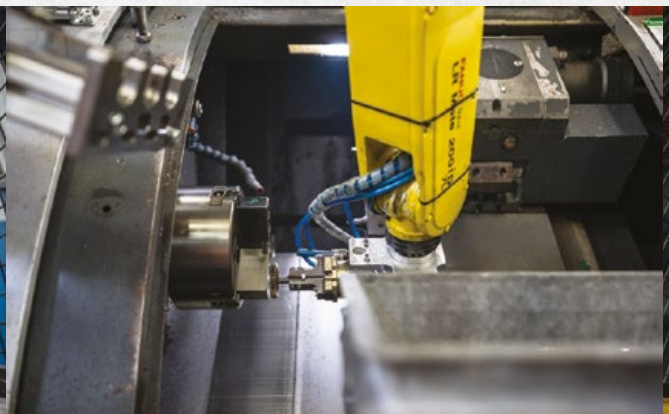
With a total of 160 employees, including 14 engineers in the R&D department, developments have been made in robotic automation and digitalization of the company. A total of 21 robots were installed in the production and quality departments. There are plans to add a further 6 to 8 robots by the end of 2019. A special software developed by the company in co-operation with its suppliers enables managers to monitor production online via 30 video cameras that are accessed through mobile devices. These combined factors have increased the company turnover by 24%, whilst at the same time reducing staff by 15%.

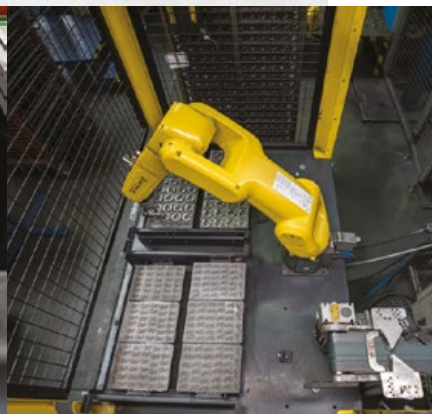
Gevorkyan is positive about its future business development, with increased resources for R&D, Sales and Marketing, the company continues to attract new business with its strategy to diversify its customer base. Automotive is targeted to represent 40% of the business.

After several years of experience in 3D printing for non-metallic parts for internal company use, Gevorkyan has invested in metal AM machines for use in tool production (mainly MIM) in Gevorkyan's tool-making subsidiary company, GPM Tools.
Prior to founding this company, A. Gevorkyan worked as a military aircraft engineer specializing in materials. Later on, he established the first privately owned PM plant in Ukraine. He strongly believes that the company is capable to use Additive Manufacturing technology for aerospace applications. The company portfolio consists of 2000 various types of part, adding about 130 brand-new components every year.



www.gevorkyan.sk/en - marketing@gevorkyan.sk - Továrenská 504, 976 31 Vlkanová, Slovakia





Magna signs its first complete vehicle manufacturing joint venture in China

Global automotive supplier Magna International Inc. has signed a framework agreement governing its electric vehicle manufacturing joint venture in Zhenjiang, China, with BAIC Group (Beijing Automotive Industry Holding Co., Ltd.) and the Zhenjiang government. The transaction, which is pending regulatory approval and other closing conditions, is expected to close in the fourth quarter of 2019.

China is the leading market for electric mobility, with around 700,000 electrified cars sold in 2017. By 2020, the number of all-electric cars on China's roads is forecast to reach around five million, helped in part by subsidies and quotas given by the Chinese government. In June 2018, Magna and BJEV (Beijing Electric Vehicle Co. Ltd), a subsidiary of the BAIC Group, announced they would jointly engineer and build premium electric vehicles for customers in China. In January 2019, the two companies opened a new engineering centre and announced the groundbreaking of a test centre in Zhenjiang.

This new joint venture in Zhenjiang is to be controlled by an affiliate of the BAIC Group and represents Magna's first investment in a complete vehicle manufacturing facility outside Europe. It is expected to combine Magna's vehicle engineering and manufacturing expertise with BAIC's local manufacturing, marketing and distribution footprint to support electric mobility in China. The new facility has the capacity to produce up to 180,000 vehicles per year.

"Magna has proven experience building complete vehicles for customers," stated Günther Apfalter, President of Magna Europe and Magna Steyr. "We are excited to work with BAIC to further strengthen Magna's e-mobility capability in the largest global market for new energy vehicles."

Zhang Xiyong, General Manager of BAIC Group, commented, "BAIC's long-term strategy, an open and sharing philosophy, and a collaborative and innovative mindset leads us toward the top partners like Magna."

The first production of electric vehicles, BJEV's ARCFOX models, is expected to launch in late 2020. The joint venture will also reportedly be capable of offering EV contract manufacturing services to other potential customers.

www.magna.com
www.baicgroup.com.cn

Atomisation for Metal Powders course scheduled for March 2020


Participants will learn more about all the current atomisation processes used to manufacture metal powders (Courtesy Atomising Systems Ltd)

Andrew Yule, Emeritus Professor of Mechanical Engineering, University of Manchester, UK, and John Dunkley, Chairman of Atomising Systems Ltd, Sheffield, UK, will hold the 13th edition of their popular Atomisation for Metal Powders course from March 5 – 6, 2020, at the Manchester Conference Centre, Manchester, UK.

The intensive two-day course combines up-to-date practical information with theory and is expected to be of value to engineers working both in metal powder production and R&D. All current atomiser types will be covered for most metals, powder types and uses. In line with the interests of previous course participants, there will again feature expanding coverage of powder manufacture and properties for Additive Manufacturing.

The course will also cover key instrumentation, essential theory and computer modelling, and look in-depth at plant design, operation and economics across the entire process chain, from melting to cooling, drying, dewatering, sieving, conveying, feeding and more.

To date, Yule and Dunkley's metal powder atomisation courses have been attended by approximately 400 registrants from sixteen countries. An early-bird discount is available to those who register for the 2020 course before October 30, 2019. A discount is also available for multiple bookings from the same company.

www.cpfresearch.com

ZF introduces new generation 8-speed automatic transmission for hybrid drives

ZF Friedrichshafen AG, Friedrichshafen, Germany, has introduced a new generation eight-speed automatic transmission for hybrid drives. Typically, hybrid transmissions are built by taking an efficient automatic transmission and replacing the torque converter with an electric motor with a higher power density, but ZF's transmission is designed specifically for hybridisation from the start.

The new transmission's modular construction system reportedly enables mild, full, and plug-in hybrid drives to achieve top performances between 24–160 kW. The power electronics are no longer designed as a separate unit, but instead fully integrated into the transmission housing without increasing the outer dimensions of the transmission. With a new, significantly smaller hydraulic control unit, ZF has created the required installation space for the electric and electronic components.

ZF stated that it estimates that at least 70% of all new vehicles in 2030 will still have an internal combustion engine (ICE). Nevertheless, a plug-in hybrid drive could considerably lower the engine's CO_2 emissions. This is contingent on electric range and electric power, both of which must allow for driving in everyday traffic with battery power only.

The company believes that it has laid the foundation for this with the plug-in model of the new generation eight-speed automatic transmission. The electric motor has a maximum power of 160 kW and a continuous output of 80 kW. The maximum torque, which can be attained without actuating the internal combustion engine, is 450 Nm, thus allowing for swift overtaking, even in e-mode.

This does not require a significant increase of the packaging size, since ZF relies on a new generation of internally developed electric motors and uses welded copper rods instead of coiled copper wire. This technology, known as the 'hairpin technique,' allows the copper fill level to be significantly increased, which has a decisive impact on the power density.

In addition to plug-in hybrids with high voltages of around 300 V, mild hybrids are also expected to play a key role in the coming decade. They have a voltage level of 48 V and allow for considerable CO_2 savings by generating power through regenerative braking recovery that can later be used as drive power.

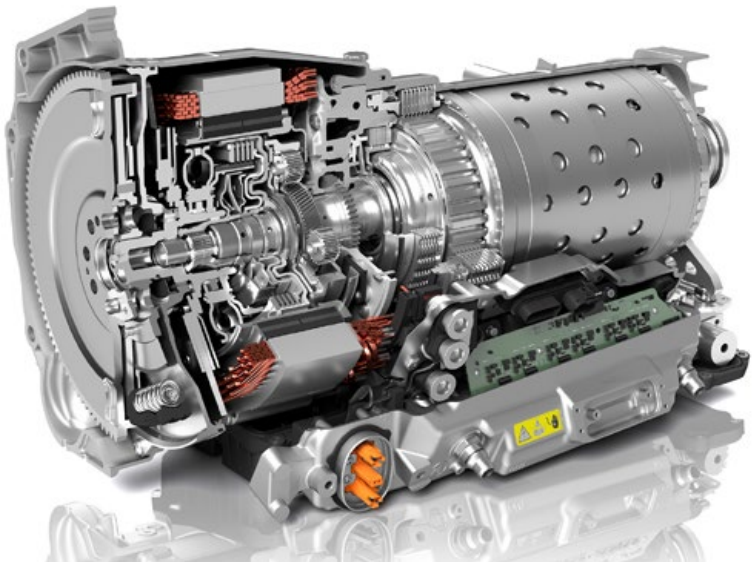
Furthermore, mild hybrids are said to lower pollutant emissions by providing additional power during launch and acceleration processes – driving conditions in which conventional internal combustion engines emit a relatively high amount of pollutants in a short amount of time. 48 V drives can be installed on several locations in the driveline. Installation on the crankshaft at the engine output (Position 1) and on the input shaft (Position 2) are particularly efficient. The new generation from ZF is suitable for both installation types. The electric motor can reach a maximum power of up to 25 kW and thus optimally support the internal combustion engine in virtually all operating parameters.

Electric motors must be controlled via power electronics, which both convert the direct current from the battery into the required alternating current and control the power and speed of the electric motor. Until now, sated ZF, these power electronics were housed separately for all series hybrid transmissions. However, with the fourth generation, ZF reports it has integrated the complete power electronics into the transmission housing for the first time ever. This is said to be a great advantage to automotive manufacturers, since hybrid drive assembly is no longer considerably more complex than that of a conventional transmission.

The hydraulic control unit in the current generation automatic transmission requires a volume of 3.1 l, but in the next generation, it will shrink to 1.8 l. This is made possible primarily by using direct shifting valves. In contrast to the electric pressure actuators that were previously used, these electromagnetic actuators no longer require additional pistons and bushings.

ZF will begin manufacturing the new generation eight-speed automatic transmission in Saarbrücken, Germany, in 2022.

www.zf.com



ZF's new generation eight-speed automatic transmission is designed for hybridisation and enables mild, full, and plug-in hybrid drives to achieve top performances between 24–160 kW (Courtesy ZF Friedrichshafen AG)

Call for papers issued for Titanium Europe 2020

The International Titanium Association (ITA) has issued a call for papers for the 8th annual Titanium Europe 2020 conference, which will take place in Dublin, Ireland, May 4 – 6, 2020.

The three-day event, organised by the ITA, aims to offer visitors insight into the current state of the industry, as well as networking opportunities for titanium producers, OEMs, distributors, fabricators and vendors who offer products and services to the titanium community.

Paper submissions are invited in the aerospace applications, industrial markets, advancement in titanium powders and other areas.

The paper submissions deadline is February 28, 2020.

titaniumeurope.org

International VDI Conference – Automotive Drives to take place in Amsterdam

The International VDI Conference – Automotive Drives, will be held in Amsterdam, the Netherlands, from November 6–7, 2019. The symposium will provide an overview of Battery Electric Vehicles (BEV), Hybrid Electric Vehicles (HEV), Fuel Cell Electric Vehicles (FCEV) and other alternative power sources for use in vehicles, as well as other alternative power sources.

The two-day event is organised by VDI Wissensforum GmbH, Düsseldorf, Germany, and will reportedly focus on finding the right 'mix' of engines and fuels to prepare for a future with reduced emissions and new, electrified powertrains. The conference is aimed at specialists, experts and professionals, particularly those working in:

- Powertrain development & technology
- Electric mobility / powertrain electrification & hybridisation
- Fuel cell technology, development & strategy
- Hydrogen business development
- Alternative fuels
- Business development
- Research & development

The programme will also discuss the political and regulatory issues, making the conference essential for professionals working in the future of powertrain development.

www.vdi-wissensforum.de

Researchers develop single-step process for manufacture of rods and tubes from aluminium powder

Researchers at the Pacific Northwest National Laboratory (PNNL), Richland, Washington, USA, have reportedly developed a new manufacturing process for the production of rods and tubes directly from high-performance aluminium alloy powder in a single step. Using a Solid Phase Processing approach, the research team stated that they have been able to eliminate several steps required during conventional extrusion processing of aluminium alloy powders, while achieving a significant increase in product ductility.

This is expected to have significant benefits for sectors such as the automotive industry, where the high cost of manufacturing typically limits the use of high-strength aluminium alloys made from powders. The team's research is described in a paper published in the June 2019 edition of *Materialia*, titled 'High Ductility Aluminum Alloy Made from Powder by Friction Extrusion'.

High-performance aluminium alloys made from powder have long been used in lightweight components for specialised aerospace applications, where cost is not a limiting factor. However, these alloys have typically been too expensive for the automotive industry.

A typical extrusion process for aluminium alloy powders is energy- and process-intensive, requiring multiple steps to mass-produce the material. First, the loose powder must be loaded into a can and degassed. The can is then sealed, hot pressed, pre-heated, and placed into the extrusion press. After extrusion, the can is removed to reveal the extruded part made from consolidated powder.

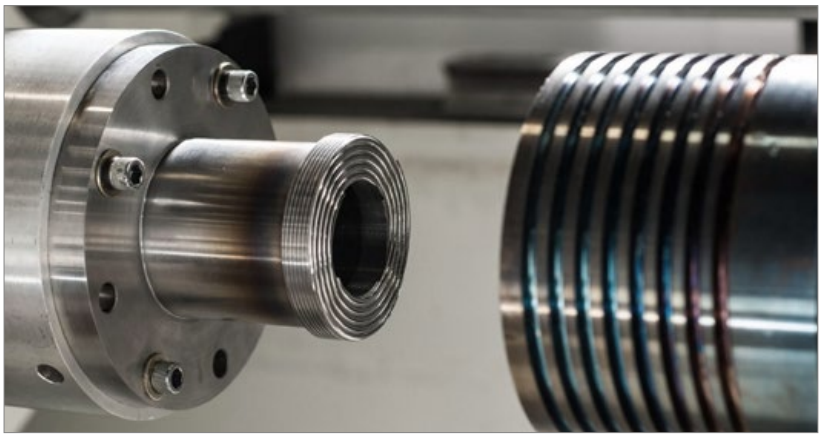
In this study, the team eliminated many of these steps, extruding nanostructured aluminium rods directly from powder in a single step using PNNL's Shear Assisted Processing and Extrusion technology, or ShAPE™. In the ShAPE process, a powder – in this case Al-12.4TM aluminium alloy powder provided by SCM Metal Products, Inc., a division of Kymera International – is poured into an open container.

A rotating extrusion die is then forced into the powder, which generates heat at the interface between the powder and die. The material softens and easily extrudes, eliminating the need for canning, degassing, hot pressing, pre-heating, and decanning.

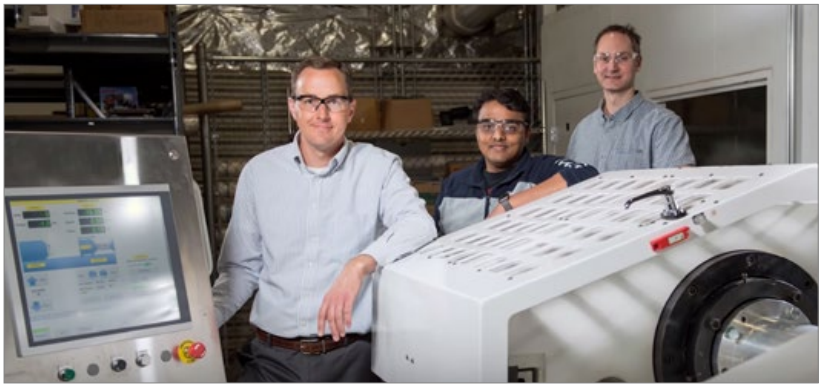
"This is the first published instance of an aluminium alloy powder being consolidated into nanostructured extrusions using a single-step process like ShAPE," stated PNNL Materials Scientist Scott Whalen, who led the study. "The elimination of both the processing steps and the need for pre-heating could dramatically reduce production time as well as lower the cost and overall embedded energy within the product, which could be beneficial for automotive manufacturers who want to make passenger vehicles more affordable, lighter, and fuel-efficient for the consumer."

Besides providing the Al-12.4TM powder, SCM Metal Products performed mechanical testing to validate the resulting material's performance. PNNL and SCM Metal Products are now collaborating on a project for DOE's Office of Technology Transitions to scale up the process for larger diameter extrusions.

www.kymerainternational.com
www.pnnl.gov



PNNL's ShAPE™ process, combined with a unique aluminium alloy powder, produced high-strength, high-ductility rods in one single process (Courtesy Andrea Starr | Pacific Northwest National Laboratory)



The research team at the Pacific Northwest National Laboratory. From left to right: Jens Darsell, Vineet Joshi and Scott Whalen (Courtesy PNNL)

WorldPM2020 / MonTreaL

World Congress on Powder Metallurgy & Particulate Materials

June 27–July 1, 2020

Held in conjunction with:

AMPM 2020 — Additive Manufacturing With Powder Metallurgy

Nb Mo Hf W Ta Ir Re Os

Tungsten, Refractory & Hardmaterials Conference

Metal Powder Industries Federation
APMI International

CALL FOR PAPERS & POSTERS

WorldPM2020

TECHNICAL PROGRAM
Held with the co-located Additive Manufacturing with Powder Metallurgy (AMPM2020) Conference and the Tungsten, Refractory & Hardmaterials Conference, WorldPM2020 attendees will have access to over 200 technical presentations from worldwide experts on the latest research and development.

TRADE EXHIBIT
The largest annual North American exhibit to showcase leading suppliers of powder metallurgy, particulate materials, and metal additive manufacturing processing equipment, powders, and products.

SPECIAL CONFERENCE EVENTS
Special guest speakers, awards luncheons, and evening networking events round out a world-class program.

Abstract submisison deadline: November 15, 2019 • Visit WorldPM2020.org

Fukuda Metal Foil and Powder Co., Ltd: Three hundred years of metal powder production in Japan

For over three hundred years, Fukuda Metal Foil and Powder Co., Ltd, has manufactured metal powders in Kyoto, Japan. As one of the oldest metal powder producers worldwide, the company has a rich history and continues to develop new materials and processes to meet present day challenges. International PM consultant Dr Yoshinobu Takeda visited Fukuda and reports on the company's past and present as an innovator in the global metal powder industry.

Fukuda Metal Foil and Powder Co., Ltd is a non-ferrous metal powder manufacturing company that has been located in Kyoto, Japan, since 1700. Established as a gold foil (leaf) manufacturer by Benseki Fukuda, gold powder was a side product of the foil production process. Scraps or chips of gold foil generated either during stamping, cutting, or decoration, were exploited for other uses as gold powder. This was the beginning of metal powder manufacturing at Fukuda [1].

As the former capital of Japan, Kyoto was an ideal location for Benseki Fukuda's business to be established (Fig. 1). During the Genroku era in the Edo period, the economy in Japan flourished in a peaceful society under the reign of the Tokugawa Shogunate. This promoted the development of culture and the arts, and the market for gold foil and gold powder flourished.

With a rich history dating back over 300 years, Fukuda is one of 639 Japanese companies reported to have been established for this length of time or more [2]. Although many European Powder Metallurgy companies also have long histories, such as SHW established in 1365, Uddeholm in 1668, Höganäs in 1797 and Boehler in 1870, none of these businesses began life as powder makers.

Fukuda today

In 1935, Fukuda Ju Shoten, as the company was then known, reorganised to become a joint-stock company and adopted a modern managerial system. The company was renamed Fukuda Metal Foil & Powder Co. Ltd., in 1940. In 2013, Shuzo Sonoda

Fig. 1 Fukuda's original headquarters in Kyoto, Japan, established in 1700, illustrated in 1883 (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

Fig. 2 Fukuda's powder production facility in Shiga, Japan (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

was appointed the company's sixth president, following Yasuhiko Hayashi, who had served as president since 2003.

Today, Fukuda offers over a thousand metal powder products, along with a wide range of metal foils and processed foil products. The company's Powder Metallurgy materials range from copper and tin powders to bronze or other alloyed or premixed powders. Supporting its manufacturing business, Fukuda has a full range of research and development capabilities, from fundamental research to application development.

"Fukuda wants to be a strong company rather than a big company," Shuzo Sonoda told the author during his visit to the company's Kyoto office. "Therefore we have been focusing on foil and powder. We will stick to this. We are a company satisfying customers' specific needs, even in niche markets. Through contacts and discussion with customers in various sectors, we identify new applications either directly or indirectly."

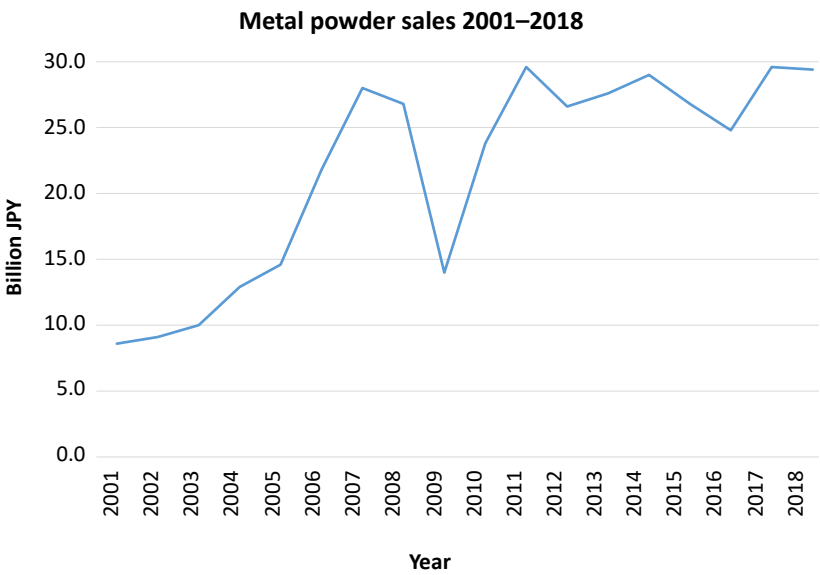


Fig. 3 Metal powder sales from 2001–2018 (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

Powder production methods currently in use include atomisation (gas, water, high-pressure water and centrifugal), electrolysis, chemical reduction and pulverisation. Besides materials for Powder Metallurgy, powders are produced for applications in conductive materials, pigments, catalysts and hard facing, bonding, sliding, friction, carbon brushes and Additive Manufacturing. Those materials are made from Cu, Sn, Ni, Co, Al, Zn, Ag, Au, Mg, etc, at production sites in Kyoto and Shiga in Japan (Fig. 2) and Suzhou in China. In total, around 20,000 ton/year of metal powders are produced at these plants.

In 2018, Fukuda reported that sales of metal powders reached 29.4 billion JPY ($271.8 million) and metal foil sales reached 26 billion JPY ($240.4 million). Metal powder

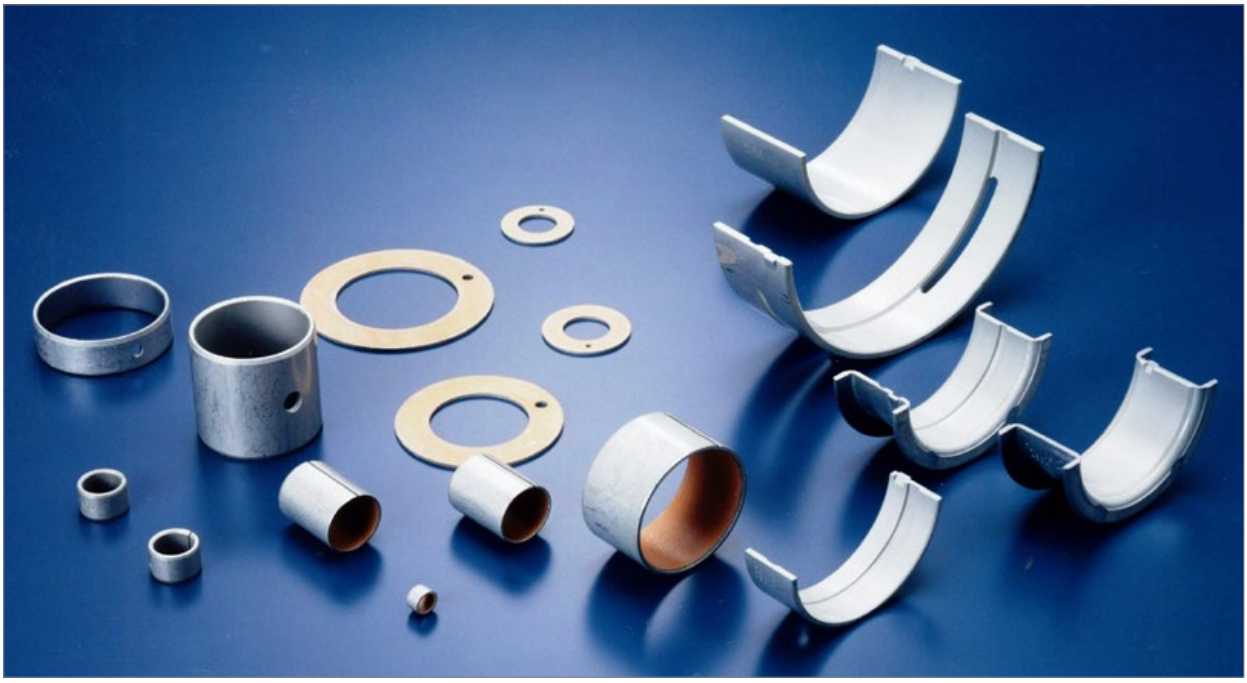


Fig. 4 Sliding bearings produced from Kelmet powder (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

exports are said to account for around 18% of this turnover. As can be seen in Fig. 3, Fukuda's Metal Powder Business has grown strongly since 2001, but has been influenced by the global economic climate.

Copper powder

In Fukuda's Metal Powder Business, its core product is now copper and copper alloy powder. The company succeeded in producing copper powder by the electrolytic deposition method in 1937, having been unsuccessful in an earlier attempt using a chemical replacement deposition method in 1932. The first application for copper powder was in the production of carbon brushes for electric motors. Later, this technology was exploited to make silver, tin and nickel powder.

Electrolytic technology paved the way for the production of electrolytic foil, which later became Fukuda's other core business. The progression from powder to foil products was the opposite of the company's development of gold powder, which began with foil production and moved into powder production.

Atomisation technology

The development of atomisation technology at Fukuda was initiated by Kaichi Fukuda, an eighth-generation member of the Fukuda family, in 1957. It was the first copper powder atomisation plant in Japan, and began by producing low-melting temperature alloy powder by air atomisation, then nickel, nickel alloys and copper alloys were made by water atomisation in 1959. In 1963, a new gas atomising plant dedicated to Kelmet (Cu-30%Pb alloy for sliding bearings) powder

Fig. 5 The gas and water atomisation control room at Fukuda's Shiga facility (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

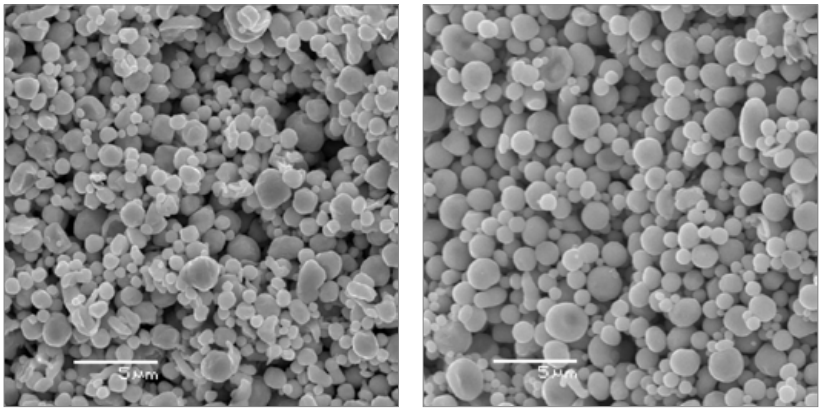


Fig. 6 Cu and Ag powder made by the ultra-high-pressure swirl water jet atomisation, Cu HWQ-1.5 µm (left) and Ag HWQ-1.5 µm (right)

	Grade (µm)	D50 (µm)	Tap density (`g/cm³)	BET (cm²/g)
Cu-HWQ	1.5	1 to 2	3.0 to 4.0	5000 to 8000
	3	2 to 4	3.0 to 5.0	2500 to 4500
	5	4 to 6	4.0 to 5.5	1500 to 35000
	10	8 to 12	4.0 to 5.5	500 to 2000
	20	16 to 24	4.0 to 5.5	500 to 2000
Ag-HWQ	1.5	1 to 2	3.0 to 4.0	5000 to 8000
	2.5	2 to 3.5	3.5 to 5.0	3000 to 4500
	5	4 to 6	4.0 to 5.5	1500 to 3500

Table 1 Powders produced by ultra-high pressure water atomisation

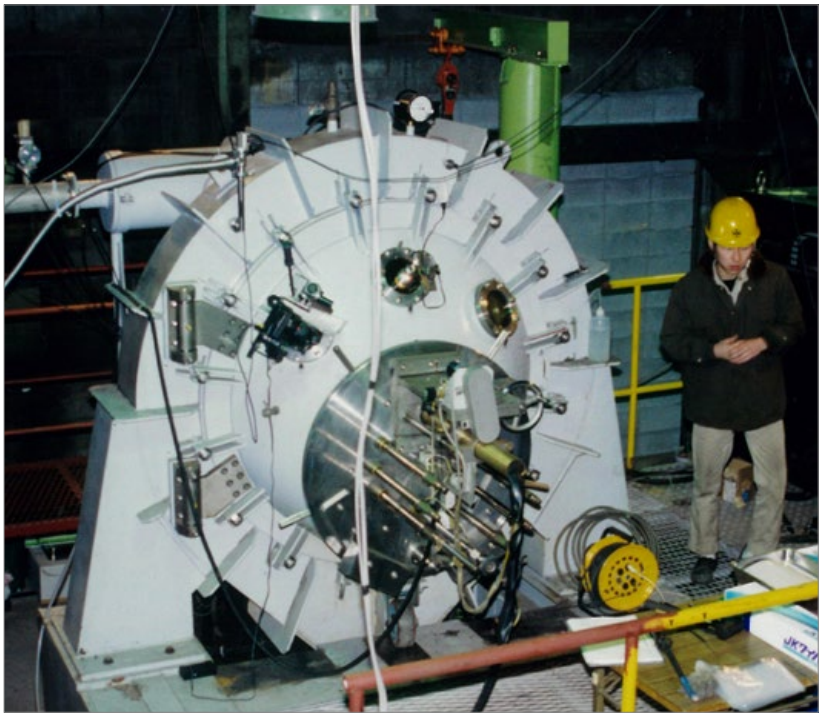


Fig. 7 PREP (Plasma Rotating Electrode Process) system (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

was initiated, following the growth of the automotive industry and corresponding growth in demand for Kelmet for engine bearings (Fig. 4).

Due to today's regulation of lead in the automotive industry, Kelmet is now used only in limited applications, such as large-size diesel engines for trucks, marine engines and construction machinery.

Ultra-high-pressure swirl water jet atomisation

Fukuda presented its ultra-high-pressure swirl water jet atomised super-fine powder at the PM2000 Powder Metallurgy World Congress, Kyoto, Japan, November 12-16, 2000. The process was commercialised in 2005 at its Shiga plant (Fig. 5). The ultra-high-pressure water jet atomisation technology was developed by T Takeda and K Minagawa of Japan's National Institute for Materials Science (NIMS) in 1985 [3] and Fukuda further developed their own Swirl Atomisation process in collaboration with T Takeda in 1989 [4]. This enabled the manufacture of D50 of single-µm Cu, Ag and Ni alloy powder with spheroidal shape, for application in the electronics, diamond tools and MIM industries (Fig. 6 & Table 1).

PREP and other powder production methods

PREP (Plasma Rotating Electrode Process) was introduced in 1993 (Fig. 7) and has since been used to produce Ti alloy powder for medical applications such as implants. A uniform droplet spray method was also introduced to make Pb-free solder balls for the electronics industry. This method enables the manufacture of balls of 80–450 µm with very tight diameter tolerance of +/- 10 µm, as shown in Fig. 8 [5].

Besides electrolysis and atomising methods, Fukuda also produces powder by pulverisation/stamping and chemical reduction. The first metal powder making method in the Edo period was rasping and later pulverising with rollers; in the early 20th century, the stamp pulverising process was introduced from Germany. This process was used

for the production of copper and brass powder. The brass powder was not for PM, but for the pigment in printing ink; upon request from the Navy, iron powders for PM were produced by this process in 1944. This was the first metal powder production specifically for PM.

Development of the chemical reduction method began in 1955 and silver powder for conductive paste was first produced commercially in 1961. Silver powder was sold as conductive paste and adhesive, supplied to electronic device makers in Kyoto, Murata Manufacturing and Kyocera in 1966. The electronic device market grew very rapidly and the consumption of such powders increased significantly (Fig. 9).

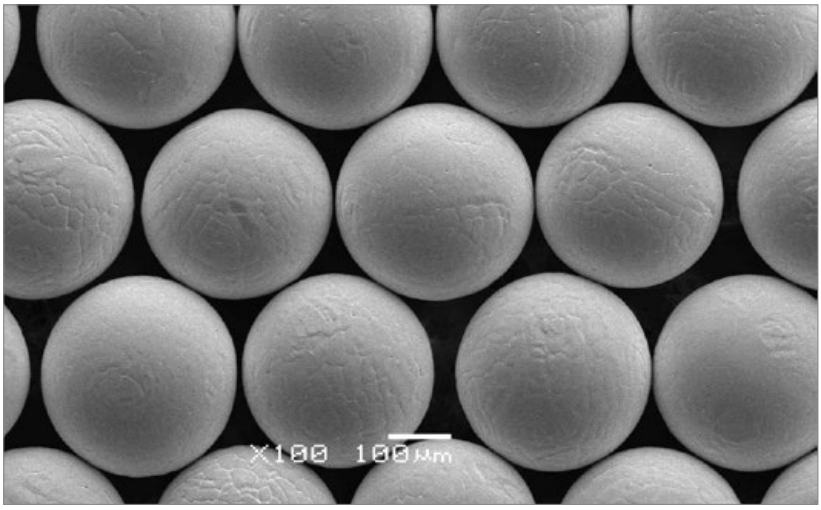


Fig. 8 Pb-free solder balls produced using the uniform droplet spray method for the electronics industry (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

Alloy development at Fukuda

Alloys for bearings

Alloy development has played a very important role in Fukuda's metal powder business. One of the outstanding achievements is press and sintered aluminium bronze (Cu-7~10mass.%Al). This alloy is known for having an excellent combination of mechanical properties and corrosion resistant properties. However, due to the strong aluminium oxide on the powder surface, sintering was not possible in the normal way. PM aluminium bronze with elemental mix was first studied by H Mitani of Osaka University in 1973 [6], who found significant swelling due to the formation of the intermetallic compound Cu_9Al_4 (γ2), which made it impossible to produce a sound sintered body. In 1973, Yokota and Mitani found that mixing nickel coated copper and Cu_9Al_4 (γ2) powder was the solution to avoid swelling, and also confirmed better bearing performance than ordinary PM bronze, particularly at higher loads [7]. However, the material was not commercialised. In 1972, AlF_3 (flux) was found to be effective in promoting sintering of Cu-Al pre-alloy powder by Inaba and Shingu [8]. Fukuda started to optimise the sintering process and powder, as there were still industrial issues to overcome in order to have consistent sintering. After a long development period [9-12], Masuoka and colleagues finally succeeded in overcoming these issues. This alloy has been used by one of Fukuda's customers, NTN Advanced Materials Co., Ltd, to produce corrosion-resistant bearings in fuel pump and EGR systems since 2013 (Fig. 10).

Cu-8Sn-9Ni, another bearing alloy, which has higher strength than ordinary bronze, was developed in 2011 [13]. The critical breakthrough for this alloy was to generate spinodal age hardening without water quenching by using a pre-alloy and quenching down to 573 K within 260 sec.

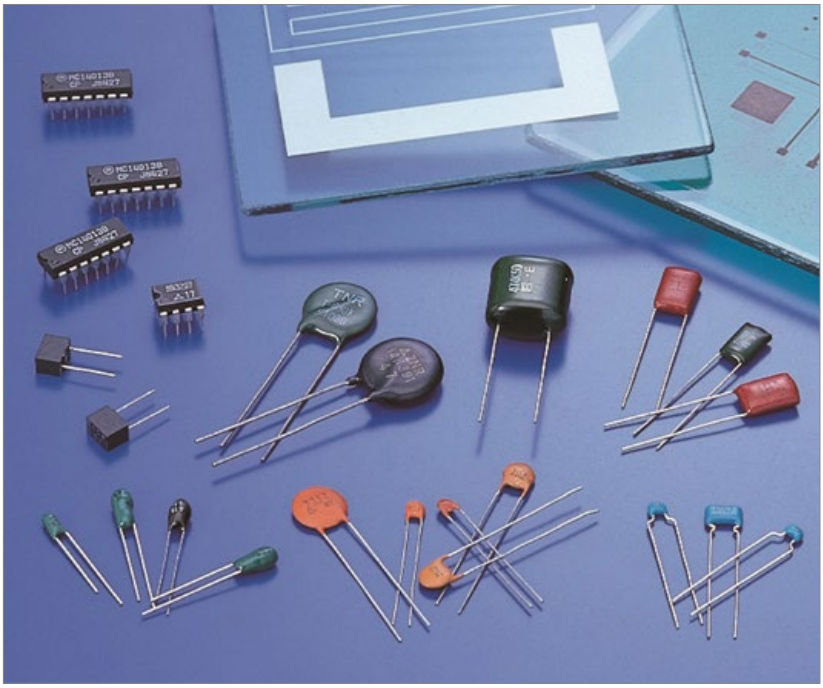


Fig. 9 Electronics products using Fukuda's silver powder conductive pastes (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

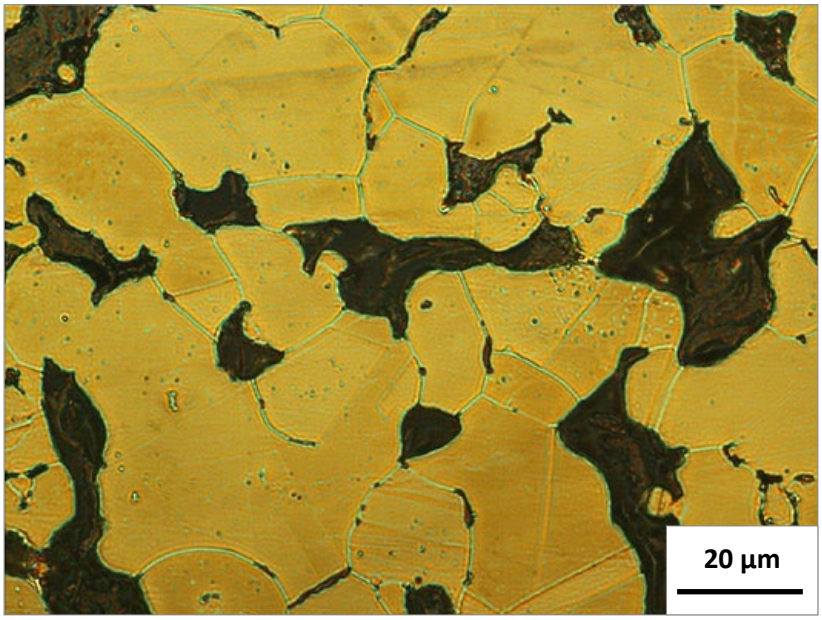


Fig. 10 Microstructure of sintered Cu-7%Al (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

Nickel-base brazing alloy

Besides standard grades of brazing filler alloys, Fukuda has developed an excellent Ni-base alloy called FP-613 [14]. This became the global *de facto* standard alloy for the brazing of stainless steel heat exchangers of vehicles: EGR coolers (Fig. 11) for turbocharged diesel engines and Atkinson cycle gasoline engines. FP-613 is Ni-29%Cr-4%Si- 6%P alloy powder made by gas atomisation. Fukuda also added several variations of the alloy, as shown in Table 2: a higher corrosion resistant alloy, a lower melting point alloy, an iron added alloy and an iron base alloy. As Fukuda also has expertise in organic chemistry for the production of conductive paste and adhesive, it also developed a brazing paste and process with its partner company [15].

Copper infiltration

An alloy for copper infiltration was first developed in 1978 as Cu-Fe-Mn. Since then, some other improved alloys were developed and FIP-K1 (premixed Cu-Fe-Mn-Zn-Si) powder is currently commonly used in Japan. This is primarily used for PM valve seat inserts. Fukuda were challenged to make Cu- or Ni-Al_2O_3 (Oxide Dispersion Strengthened alloy) by a new process not using internal oxidation [16]. The developed process used alkoxide hydrolysis to deposit fine alumina particles on the surface of copper powder. In 1983, monthly shipments of these materials reached four tons.

Powders for surface coating

Powder for surface coating is another important application of the metal powder business, with its brand name of Fukudaloy. The development started through the request of the domestic heavy industry in 1961 to make self-fluxing alloy powder. Fukuda had struggled to find a way to add boron, as pure boron was more expensive than gold. Then, it challenged its own method using a thermite reaction; a mixture of aluminium powder, chromium oxide powder and boron oxide powder was heated and chromium boride was generated by an explosive reaction.

After obtaining raw chromium boride, Fukuda exploited its existing powder process technologies to refine its purity and homogeneity. Chromium boride was crushed into powder, washed with water and then processed by pickling. Using its own boron source, it managed to make the self-fluxing alloy powder by water atomisation. Based on this successful development, it also developed a welding rod alloy.

Since 1989, laser cladding technology has become popular and Ni-base and C- base alloys have been developed with Toyota to be used for surface coating of engine valves [17]. A copper-base alloy for laser cladding inlet valve seats was also co-developed with Toyota [18]. Laser clad valve seats replaced PM valve seat inserts, but metal powder still plays a crucial role. Due to this success, the new generation alloy for this application was developed by Toyota and used in TNGA (Toyota New Global Architecture) engines (Fig. 12).

(Grade)		Composition (mass%)							Melting Point (C)	
		Ni	Cr	Si	Fe	P	Cu	Mo	Solidus	Liquidus
Ni Base Standard	FP-613	Bal.	29	4	-	6	-	-	980	1030
Higher Corrosion Resistant	FP-661	Bal.	20	2.5	-	6.5	2	10	970	1020
Lower Melting Point	FP-615	Bal.	25	4	-	5.9	10	2.3	975	985
Fe Containing	FP-633	Bal.	27	5	19	6	-	-	1000	1030
Fe Base	FP-641	15	18	5	Bal.	6.5	2	2	1030	1060

Table 2 Variations on the Ni base brazing alloy (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

In order to further differentiate itself, and to add more value, Fukuda also focused on organic surface coatings on metal powder, particularly for the electro-conductive paste. The company's expertise in organic chemistry contributed to the granting of patents using organic titanate, aluminate and amine.

Fig. 11 An EGR cooler brazed with FP-613 (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

A clear vision and customer focus

The majority of Japan's businesses over three hundred years old are made up of Sake breweries and Ryokan (Inns), with only a limited number of companies having industrial backgrounds. Companies such as Sumitomo and Oigo Works (which produces Japanese temple bells), as well as Fukuda, are the exception.

So, how has Fukuda survived for more than three centuries? According to a study of thirty-two similarly long-lived companies in Japan, the economist H Funabashi found eight common factors in their management style [19]: clear vision, a long-term point of view, human-focused management, customer focus, corporate social responsibility, innovation, frugality and inherited values. These eight things are not unusual in terms of modern management, but it is notable that they have been maintained for centuries.

A philosopher named Baigan Ishida wrote a book on the ethics of business that found popularity all over Japan. It is believed that Renseki, the second generation of the Fukudas, also learned from this book and wrote his Tokiwa, Ie-no-Nae (translated as Family Seedlings), which specifies various principles, disciplines, systems and annual events that the master of the family should observe and implement. The word 'Tokiwa' means "things that remain unchanged." This essentially represents the founding management policy that has been handed down to successive generations and is still practised by the management at Fukuda today.

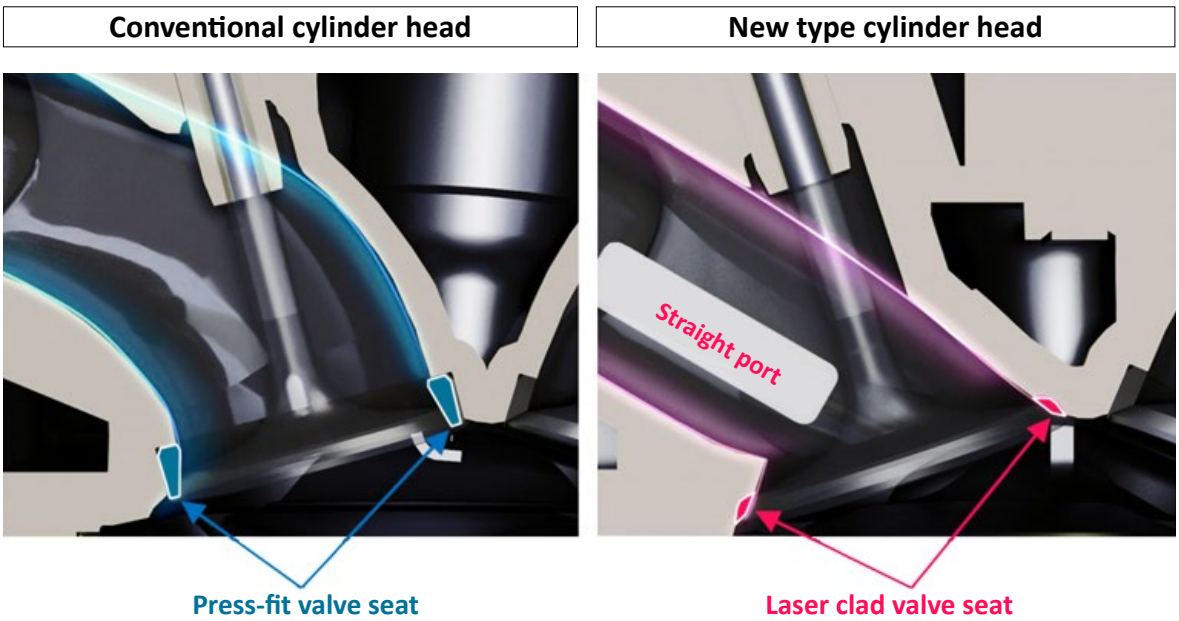


Fig. 12 Laser-clad engine valve seat (right) and conventional PM valve seat (left) (Courtesy Toyota | Central R&D Labs)

Fig. 13 PM pantograph slider and PM brake pads (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

Adapting to a changing market

In the late 19th century, when the Edo period ended its Shogunate reign and the Meiji period began, the market for traditional gold and silver foil shrunk. On the other hand, the market for gold-coloured ink grew as industrial printing technology was introduced to Japan from Europe. This ink needs brass powder as its pigment; Fukuda introduced the stamp milling method in order to replace manual operation and to increase production capacity, meeting the revolutionary market change with new technology, even from the beginning of industrialisation. The brass powder business continued growing and supported the company even during the difficult period following World War II.

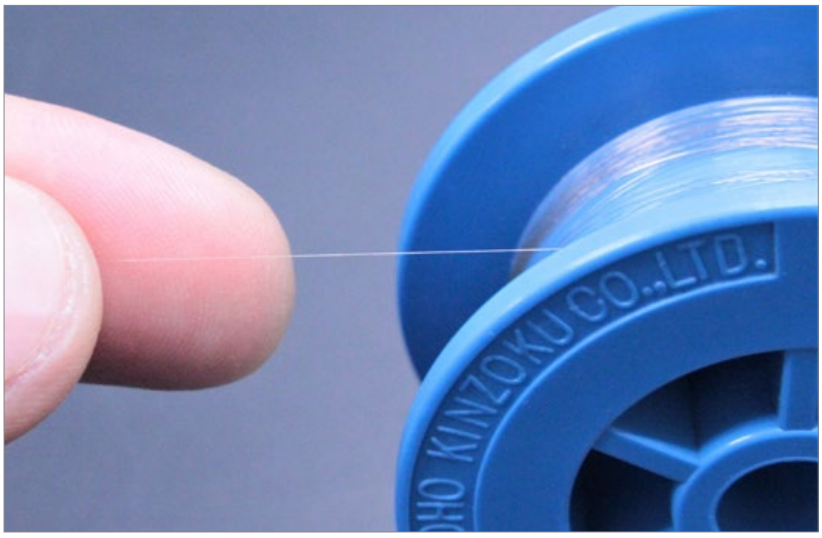


Fig. 14 This 30 µm diameter wire was produced by Toho Metal Industries using rapidly-solidified high-strength Mg-Zn-Y alloy (Courtesy Toho Kinzoku Co., Ltd)

Ongoing development and expansion into new markets

The company has met many production challenges over the course of its history, some of these having been mentioned above. Other examples include the development of an electrolytic copper powder that contributed to making pantograph sliders (the copper contacts between the electric power cable and the train) for Japan National Railway since 1947 (Fig. 13). Fukuda cooperated to establish Japan Powder Metallurgy Co., Ltd. to manufacture this product. Later, in 2002, this company merged with Tokyo Sinter Metals and became Fine Sinter Co., Ltd.

Further development of powder for cold deposition, nanoparticles, and rapidly-solidified high strength Mg-Zn-Y alloy [20] was conducted as a collaboration with Y Kawamura of Kumamoto University, as part of the project ACT-MS (Acceleration Transformative research for Medical innovation-Setup Scheme by Japan Agency for Medical Research and Development). Using the alloy, 30 µm diameter wire, having 788 MPa ultimate tensile strength, was successfully produced by Toho Metal Industries Co., Ltd. This product is expected to be used for medical applications such as stents, bio-absorbable sutures, etc (Fig. 14).

Fine powder

Very fine particles are an important raw material for the MLCC (Multi-Layer Ceramic Capacitor). Powder of 1 µm diameter can be made by Swirl Atomisation, but recently even finer powder has been requested. To make spherical nanoparticle powder, Fukuda has collaborated with Kyoto University. The new method is the femtosecond laser ablation in a liquid, which enables the manufacture of nanoparticles of metals or alloys in spherical shape (Fig. 15) [21].

New technologies offer new challenges

It is obvious that Fukuda is a company capable of meeting the demands of a dramatically changing industry. It is now meeting challenges in new areas such as photovoltaic power generation, EVs, robotics, thermoelectric elements, magnetic refrigeration, smart phones, etc, by exploiting its competence in metal powder, foil and organic chemistry.

International expansion

Fukuda was the first Japanese metal powder manufacturer to establish a facility in China in 2007. This was based at its electrolytic copper foil facility in Suzhou, itself established in 1994.

In the UK, Fukuda established a joint venture in 1989 with Cookson to form Cookson Fukuda Metal Ltd. The company produced electrolytic copper foil until its close in 2004. Currently, Fukuda has no other metal powder plants abroad, except in China.

Building success based on R&D

Discussing the value of the company's research and development activities, Yoshiro Arami, Fukuda's Technical Director, told the author, "We let our researchers challenge new themes freely with patience. The reason why we do so is that if we have a variety of new technologies and products on our shelves with a completion level of 80%, we can easily cooperate with customers to satisfy their new needs without a long lead time."

This goes some way to explaining the company's successful development and positive reputation with its customers. In Kyoto, Fukuda co-exists with several well-known new manufacturing companies, such as Kyocera, NIDEC, Murata, Nichicon and Omron; and, as Sonoda noted, both new and historic companies in Kyoto share a strong drive to be the global number one in their field. A look at Fukuda's past and present suggests that it has the experience, expertise and ethos to not only maintain, but enhance its position as a metal powder supplier in Japan and beyond.

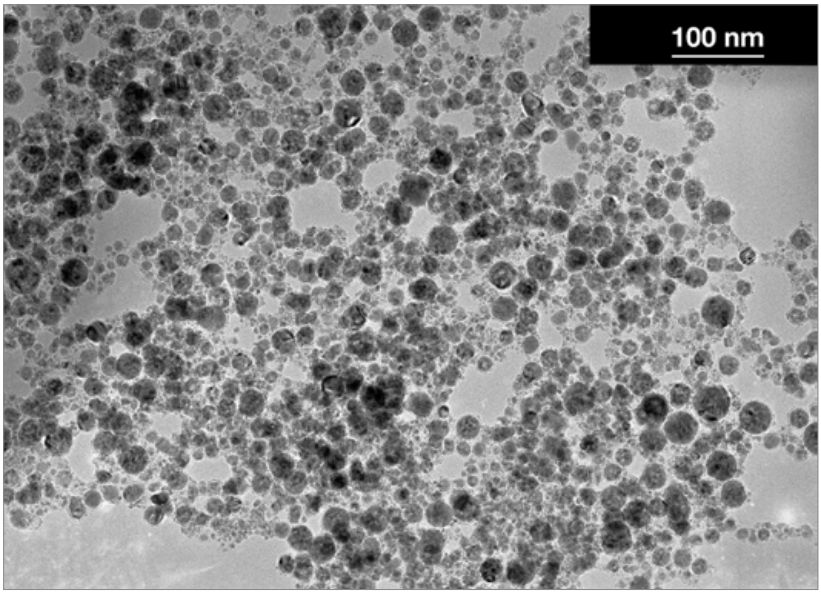


Fig. 15 Metal nanoparticles made by the laser ablation method (Courtesy Fukuda Metal Foil and Powder Co., Ltd)

Author

Dr Yoshinobu Takeda
International PM Consultant
Member of JPMA, JSPM, EPMA, APMI and international committee member of ISO TC-119
Email: ilikepmtakeda@yahoo.co.jp

Contact

Fukuda Metal Foil and Powder Co., Ltd,
20 Nakatomi-cho,
Nishinoyama, Yamashina-ku,
Kyoto 607-8305,
Japan

Contact:
www.fukuda-kyoto.co.jp/en/inquiry

Website: www.fukuda-kyoto.co.jp

References

[1] 300 Years History of Fukuda Metal Foil and Powder Industries., Ltd (2000)

[2] www.tsr-net.co.jp/news/analysis/20161202_01.html (retrieved 2019/05)

[3] JPA 1985-152605

[4] WO 99-33598

[5] JPA 2002-317211

[6] H. Mitani, *J. of JSPM 20*, No. 1 (1973) 113-120

[7] M. Yokota and H. Mitani, *J. of JSPM 20*, No. 4 (1973) 107-112

[8] T. Inaba and Y. Shingu, *Proceedings of JSPM Spring meeting* (1972) 63

[9] S. Masuoka and et.al., *J. of JSPM 49*, No. 11 (2002) 1003-1008

[10] Ibid, 55, No. 1 (2008) 64-66

[11] Ibid, 55, No. 6 (2008) 464-469

[12] Ibid, 61, No. 8 (2014) 403-409

[13] M. Tanaka, *J. of JSPM 58*, No. 9 (2011) 535-541

[14] JPB 1996-022472

[15] WO2002/053318

[16] Y. Arami and et.al, *J. of JSPM 34*, No. 6 (1987) 264-268

[17] JPA 1990-117797, JPA 1993-084592 and JPA 1993-271841

[18] JPA 1992-131341 and JPA 1996-225868

[19] www.nippon.com/en/features/c00615/leading-the-world-in-longevity-japanese-firms-in-business-for-a-century-or-more.html (retrieved 2019/05/01)

[20] www.mrc.kumamoto-u.ac.jp/en/1640/ (retrieved 2019/5/3)

[21] K. Kamibayashi et.al. *J. of JSPM 64*, No. 12 (2017) 667-672

PM CHINA 2020

The 13th Shanghai International Powder Metallurgy Exhibition & Conference

March 24th~26th, 2020

Shanghai World Expo Exhibition Center

Convergence of Cutting-edge Technology & Products

Organizer UNIRIS EXHIBITION SERVICE

Tel: +86 20 8327 6369/6389 +86 4000 778 909
Email: pmchina@unifair.com pmchina@unirischina.com

Strategies and initiatives for cost-affordable PM Ti alloys: Compositions and manufacturing

In this article, Dr Leandro Bolzoni of the University of Waikato, New Zealand, presents an overview of the progress made towards more affordable processing of Ti-based materials via thermomechanical powder consolidation based on the cost-effective hydride-dehydride powder. In particular, he presents examples of initiatives taken with respect to the investigation of the design of cost-effective (wrought-equivalent and non-standard) chemical compositions, such as low-cost Fe-bearing Ti alloys, and on the development and optimisation of Powder Metallurgy manufacturing processes, both individually and in combination.

Lowering material cost, increasing processing efficiency and optimising the manufacturing route, while maintaining high levels of static and dynamic-loading properties, as well as appropriate *in operando* performance (e.g. corrosion resistance), is the way forward in expanding the applicability of Ti in industry, especially in cost-driven sectors such as automotive and consumer goods.

The attractiveness of titanium and its alloys for industrial and engineering applications is based on many factors, but can be summarised as: "the combination of properties that each individual alloy provides". Among these properties are included: 1) excellent corrosion resistance in a variety of highly aggressive environments and biocompatibility with human body fluids, both of these being based on Ti passivity (i.e. formation of an extremely thin stable superficial oxide layer that isolates the bare metal from the operating environment, thus protecting it from corrosion); 2) a wide range of high mechanical performance, adjustable through the selection of appropriate alloying elements and manufacturing methods (including thermomechanical hot deformation and heat treatments); 3) lightweight capability, as the density of Ti ($4.51 g/cm^3$) is approximately 60% that of Fe ($7.87 g/cm^3$), the main structural engineering metal, but with equivalent or higher levels of mechanical properties, meaning that substituting Fe with Ti can easily result in a saving of 40% of the overall weight of the

Potential for titanium in automotive applications

- Engine components
- Gearbox
- Brake systems
- Pumps
- Valves & retainers
- Transmissions
- Springs
- Body panels/fixtures
- Exhaust systems
- Wheels
- Chassis
- Battery technology
- Turbochargers

- Fasteners/bolts
- Rocker arms
- Connecting rods
- Distribution systems

- Roller gears
- Filters
- Torsion bars
- ... and many more!

Fig. 1 Low-cost titanium alloys could open up new applications in the automotive sector

Fig. 2 The use of near-shape Powder Metallurgy titanium can offer significant cost and weight savings. This rocker arm was hot forged starting from a powder compact preform

Fig. 3 Thermomechanical powder consolidation of Ti alloys permits the easy manufacture of high endurance and performance consumer goods. This knife blade was thermomechanically manufactured starting from HDH Ti powder as base material

structure; the combination of points 2 and 3 provides Ti with the highest specific mechanical properties (strength/density) among structural metals; and 4) the ability to maintain high levels of mechanical performance at relatively high operating temperatures, generally up to around 600°C [1, 2].

Currently, titanium is still primarily used only in highly demanding technology industries (such as aerospace or biomedicine), due to its relatively high cost [3]. The extraction and manufacturing of Ti is often much more energy, labour and capital intensive in comparison with competing structural metals.

The advantage of Powder Metallurgy

The use of Powder Metallurgy in the manufacturing of products from particulate materials results in a high yield of materials (low wastage), often with reduced machining (due to net-shape production) and lower energy usage. All these aspects are significant when processing an expensive, difficult-to-machine, high-melting temperature, reactive metal like Ti. Froes *et al.*, identified that cost reduction for Ti components can be achieved through developing new extraction processes and via the implementation of creative physical metallurgy techniques such as PM [4].

Pre-alloyed and blended elemental

Two major approaches can be used to manufacture PM Ti alloys depending on the type of starting powder: pre-alloyed (generally atomised spherical powder particles), where each particle has already the required chemical composition, and blended elemental (BE) where a low-cost Ti powder such as hydride-dehydride (HDH) powder is mixed with the desired alloying elements (either in the form of elemental powders or master alloys) for its consolidation through shaping via cold uniaxial press and sintering (P&S). Specifically, the latter (i.e. BE P&S) is recognised as the most cost-effective alternative [4].

This article therefore aims to provide an overview of the strategies adopted and the initiatives under investigation to successfully manufacture low-cost, high performance PM Ti alloys via thermomechanical powder consolidation in the TiTeNZ (Titanium Technologies New Zealand) project, a research platform enabled by funding from MBIE, the Ministry of Business, Innovation and Employment of New Zealand.

Titanium Technologies New Zealand: Setting the scene

In the TiTeNZ project, maximisation of cost reduction for the manufacturing of affordable Ti alloys is individually and jointly targeted via the reduction of the intrinsic cost of the alloy, as well as through the development of enhanced manufacturing processes. In particular, the BE approach is chosen as it allows design and simple adjustment of the base alloy composition [5]. Hot thermomechanical deformation processing (TMD) is used, if required, to enhance the performance of cost-effective PM Ti alloys.

To support successful industrial uptake and scalability, effort is also

being focused on exploring alternative consolidation techniques for improved sintering cycles, which are more efficient, especially if they can be combined with TMD. For each of the two main research areas, alloys and process development, different subset initiatives are briefly presented in this article, although in most cases there is an innovation crossover between the two main areas.

Compositional matters

Early and current literature on the processing of Ti alloys via PM (especially that related to the investigation of novel techniques such as Additive Manufacturing) is centred on proving that wrought-equivalent Ti alloys with similar mechanical properties to ingot metallurgy (IM) alloys can be successfully manufactured via different PM methodologies, including Press & Sinter (P&S) [6-8], Metal Injection Moulding (MIM) [9-11], Hot Pressing (HP) [12-14], Hot Isostatic Pressing (HIP) [15-17] and Additive Manufacturing (AM) [16, 18, 19].

Specifically, literature is dominated by the alloy Ti-6Al-4V and the reason is twofold: 1) Ti-6Al-4V still constitutes more than 50% of the overall Ti market and its performance under different conditions (IM, heat treated, etc.), loading (tensile, fatigue, creep, etc.) and environments (corrosion, oxidation, etc.) are well quantified and available for comparison, and 2) in most cases, Ti-6Al-4V is the only (or one of few) standard compositions available commercially (eg as gas atomised spherical powder for AM). Therefore, the initiatives undertaken and discussed are divided into wrought-equivalent PM and non-standard Ti alloys. Both lean (such as the α+β Ti-6Al-4V and Ti-5Fe alloys) and heavily alloyed (such as Ti-5Al-5V-5Mo-3Cr, also known as Ti5553) Ti-based compositions are investigated to quantify the efficacy of the BE approach.

Wrought-equivalent PM Ti alloys

In a recent review [20], it was highlighted that, while there is plenty of literature available on the static behaviour (mainly tensile properties of Ti-6Al-4V [21]) of PM Ti alloys, the topics of fatigue and fracture toughness, which are critical parameters for materials selection and structural design optimisation (especially for newly-developed materials processed via novel manufacturing methods), have been largely overlooked due to their more complex nature.

The most remarkable difference between wrought and PM Ti alloys is generally the presence of residual pores left behind by the sintering process, defects that have a strong negative impact on the mechanical properties in general (e.g. strength) and on the ductility/toughness of the material in particular as they act as stress concentration sites, reduce the total area of material actually withstanding the applied load and provide an easy pathway for crack propagation. If the porosity level is below 2%, standard requirements for static applications are usually met, but this is not sufficient for the great majority of engineering components, which are commonly subjected to more complex cyclic and bi-/tri-axial loadings. Critical properties such as fatigue strength and fracture toughness have then to be optimised

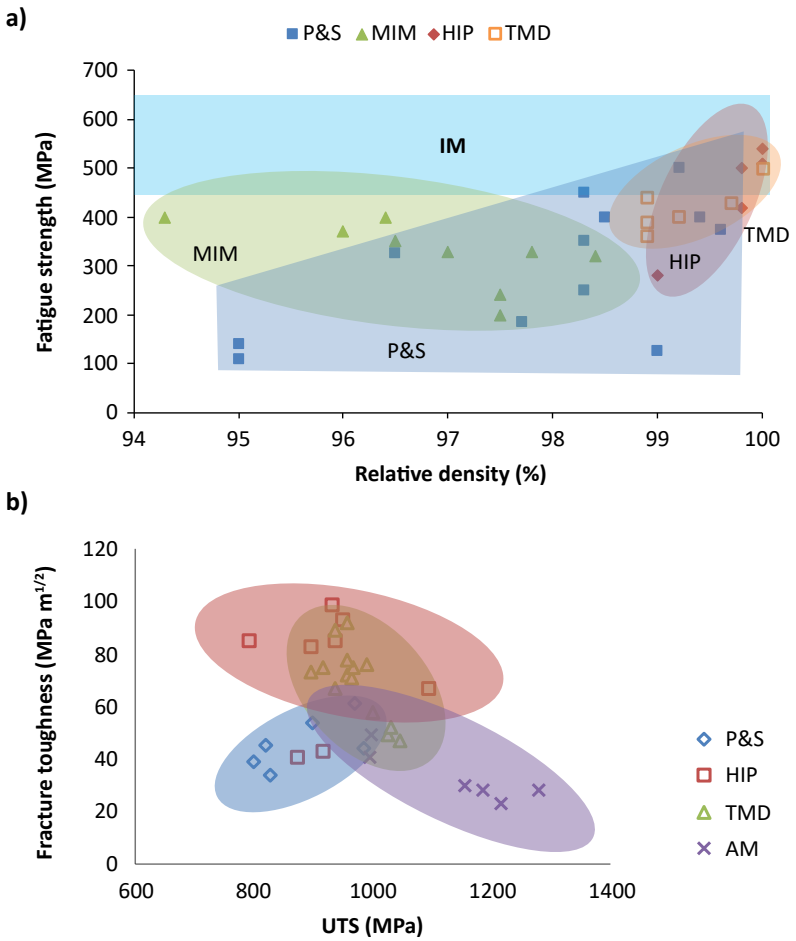
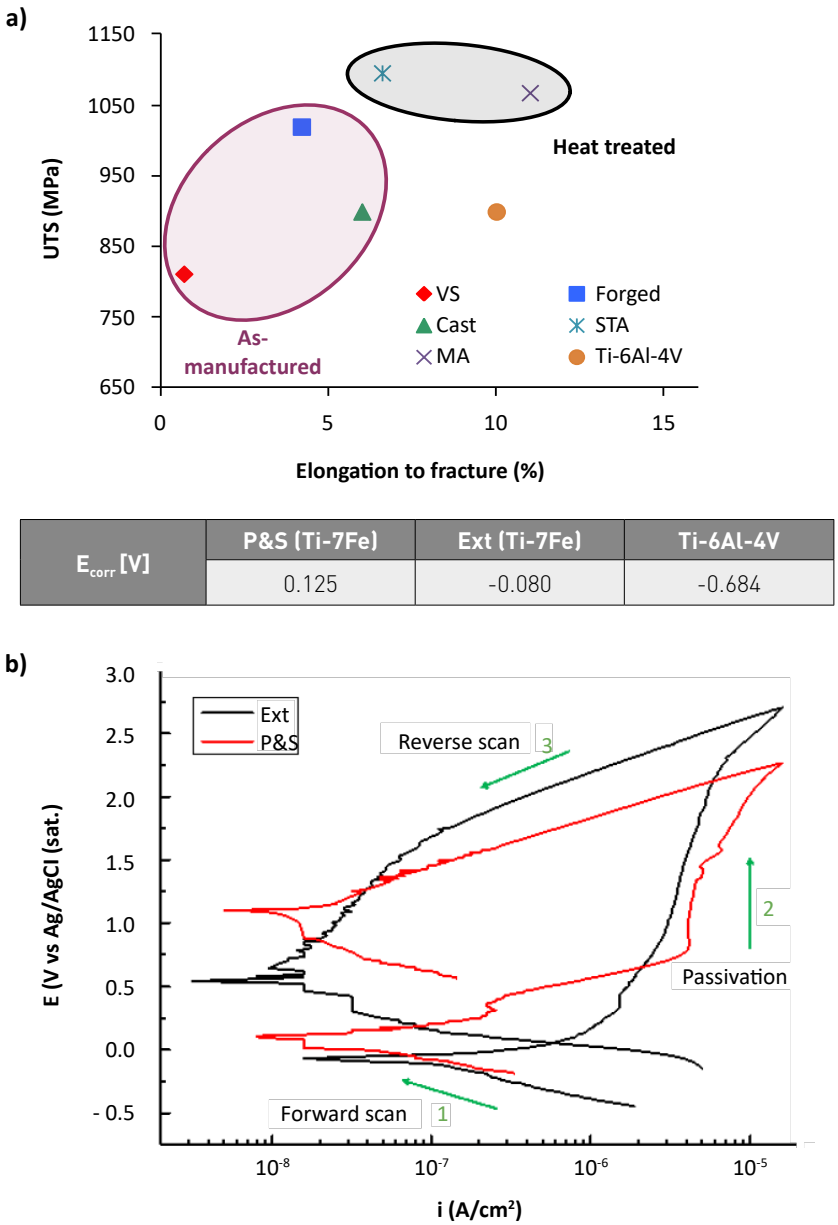


Fig. 4 Representative results related to the understanding of dynamic-loading properties of PM Ti-6Al-4V alloys: a) relative density vs fatigue strength [20], and b) fracture toughness vs ultimate tensile strength [20]. Legend: IM - Ingot Metallurgy, P&S - Press and Sinter, MIM - Metal Injection Moulding, HIP - Hot Isostatic Pressing, TMD - Thermomechanical Deformation, and AM - Additive Manufacturing (Courtesy Elsevier)



E_{corr} [V]	P&S (Ti-7Fe)	Ext (Ti-7Fe)	Ti-6Al-4V
	0.125	-0.080	-0.684

Fig. 5 Representative results of thermomechanical processing of wrought-equivalent PM Ti alloys: a) ultimate tensile strength vs elongation to fracture of BE Ti-5Al-2.5Fe alloy (legend: VS - Vacuum Sintered, STA - Solution Treatment and Ageing, and MA - Mill Annealing) [22], and b) polarisation curves of PM Ti-7Fe alloy (legend: Ext -Extruded, and P&S - Press and Sinter; adapted from [23]).

and this has to be done based on the trade-off that, as the crack initiation resistance (i.e. tensile and fatigue) of an alloy increases, its crack growth resistance (i.e. toughness) decreases.

The fatigue strength of PM Ti alloys is significantly influenced by the presence of porosity, microstructural inhomogeneity, coarse α grain boundaries or any other sort of defect which can act as a crack initiation site; defects that depend on the chosen processing route.

Our initiatives are focused around near-equilibrium solid-state TMD PM processing via forging and extrusion because they permit the simultaneous improvement of mutually exclusive dynamic-loading properties such as high cycle fatigue strength and fracture toughness, through the achievement of fully dense materials.

From Fig. 4a) it can be seen that the presence of a very small amount of residual porosity (< 1%) leads to a significant variation of fatigue strength, represented by the scatter band of the IM Ti-6Al-4V alloy. Once porosity is no longer the prevalent factor, fatigue strength is governed by the slip length, which is related to the diameter, size and width of the α and β phases present, where shorter slip lengths are associated with refined microstructures. Fracture toughness of Ti alloys is highly dependent on the microstructural features as demonstrated by the 30-100 MPa·m$^{-1/2}$ K_{IC} range of wrought Ti-6Al-4V alloy.

Residual porosity has a remarkable effect on resistance to crack propagation, where the higher the relative density of the PM Ti alloy, the higher both tensile strength and K_{IC}, especially if the pores are scattered and isolated so as not to interact with each other. However, once fully dense materials are obtained, such as for materials obtained via TMD, then the crack initiation/propagation trade-off governs the mechanical response of the alloy (Fig. 4b).

TMD can be successfully used to enhance the performance of cost-effective PM Ti alloys, as demonstrated by the comparison of the mechanical properties of the wrought-equivalent Ti-5Al-2.5Fe alloy made via PM starting from HDH Ti, atomised Al and carbonyl Fe elemental powder (Fig. 5a). In particular, powder forging can efficiently increase the strength and ductility simultaneously via the sealing of the residual porosity and heat treatments such as STA (solution treatment and ageing) and MA (mill annealing) can be used to further tailor the mechanical behaviour, achieving better overall combinations of properties in comparison with wrought Ti-5Al-2.5Fe and Ti-6Al-4V alloys [22].

A survey of literature regarding wrought-equivalent and non-standard PM Ti alloys highlights that the characterisation of the response to *in operando* environments (e.g. corrosion and oxidation resistance) of these alloys has largely been

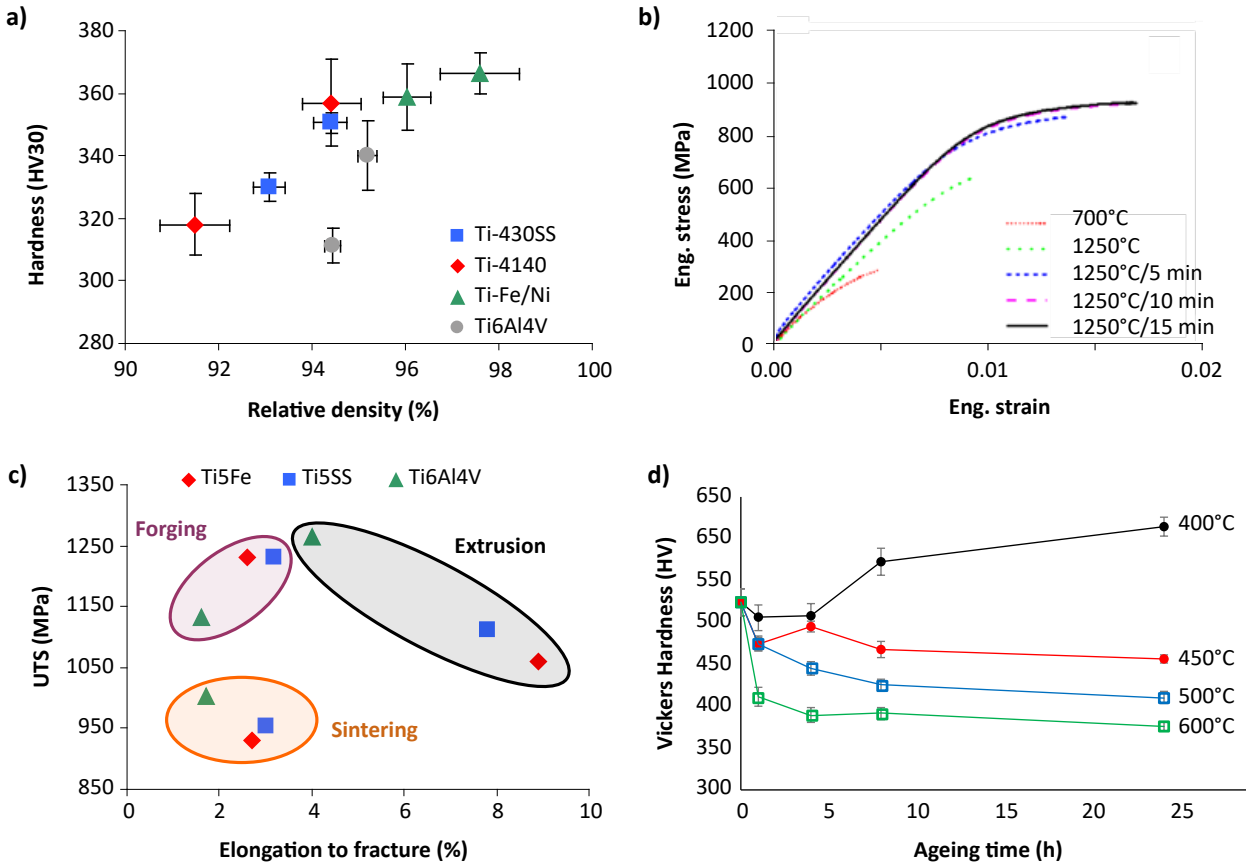


Fig. 6 Representative results for the processing of low-cost Fe-bearing PM Ti alloys: a) hardness vs relative density for P&S alloys developed with the addition of commercial ferrous powders; adapted from [25], b) engineering stress-strain curves of the reactive induction sintered Ti-5Al-2.5Fe alloy [33], c) UTS vs elongation for thermomechanically processed alloys via forging and extrusion (note: Ti5SS, addition of 5 wt.% of 316L stainless steel powder as Fe source) [34], and d) variation of the hardness of a low-cost metastable β alloy for different ageing conditions [35]. (Courtesy Elsevier).

ignored, even though this knowledge is crucial for industrial uptake of these materials. The comparison of the polarisation curves of P&S and TDM Ti-7Fe alloys shown in Fig. 5b) indicates that there are differences in the corrosion behaviour dictated by the PM processing route chosen, but that both materials show a negative hysteresis loop without undergoing passivity breakdown. Specifically, the P&S material has higher corrosion potential and thus better corrosion resistance in diluted Harrison aqueous solution [0.35 wt% $(NH_4)_2SO_4$ + 0.05 wt% NaCl], which is typically used to simulate aeronautical environments, but the extruded material has a larger passivation region. However, the notable aspect is that the values for these Fe-bearing PM Ti alloys are similar to or even better than those reported for the Ti workhorse (i.e. -0.684 V [24]).

Low-cost Fe-bearing PM Ti alloys

A strategy to manufacture more cost-affordable Ti alloys is to directly lower the intrinsic cost of the material by using cheaper alloying elements than those ones currently used. The choice of these elements is dictated by different factors, including their price/availability, their effect on the microstructure and properties of Ti alloys (α, β isomorphous and β eutectoid stabilisers), the formation of brittle phases, etc. Our effort is primarily focused on the development of low-cost Fe-bearing PM Ti alloys, as Fe is extremely abundant and cheap, well below the average cost of Ti [25]. Moreover, ferrous powders, already optimised for their processing via PM, are readily available in the market. Fe is the strongest β stabiliser, and thus is very effective in creating novel alpha+beta Ti alloys, and is a fast-diffusing element in Ti (three to five orders of magnitude faster [26, 27]) as well as an enhancer of the self-diffusion of Ti [28]. Consequently, Fe can perform as a sintering aid to promote the densification of the alloy. However, Fe is a eutectoid β stabiliser and can therefore lead to the formation of brittle intermetallic phases [29].

The different initiatives around low-cost Fe-bearing PM Ti alloys are thus centred around quantifying the processing response and properties of different near α, α+β and metastable

β Fe-bearing PM Ti alloys, processed in a variety of ways including: 1) a conventional P&S route entailing vacuum sintering; 2) the use of alternative sintering techniques; 3) the enhancement of the microstructure and mechanical behaviour via TMD, and 4) the development of appropriate heat treatments for this new class of alloys.

The advancements made in the understanding of the design, manufacturing and properties of low-cost Fe-bearing PM Ti alloys, produced via the simple P&S route using the addition of commercial ferrous powders (i.e. 430 stainless steel [30], 4140 steel [31], and Fe/Ni [32]), has recently been presented elsewhere [25]. Generally, it is found that the use of these ferrous powders does not compromise the compressibility and handling, the homogenisation of the alloying elements and the densification of the materials are enhanced (due to both fast diffusing elements and small particle size) and the relative density values and mechanical properties are comparable to those of the titanium workhorse alloy Ti-6Al-4V [8], as can be seen in Fig. 6.

Regarding the use of alternative sintering techniques, one which is under development is reactive induction sintering, and its applicability has been studied with regard to the BE Ti-5Al-2.5Fe alloy, starting from Ti powder (<75 μm, >99.5%), Al powder (45-75 μm, >99.7%), and carbonyl iron powder (5-9 μm, >99%). It is demonstrated that a completely homogeneous distribution of the alloying elements and a Widmanstätten microstructure, typical of α+β Ti alloys, is obtained via reactive induction sintering using a short dwell time of 5 min at the sintering temperature of 1250°C [33]. As typical for PM alloys, the tensile strength and elongation to fracture increase when increasing the sintering temperature or the isothermal holding time (Fig. 6b).

Thermomechanical processing, by means of β hot forging and β hot extrusion, of low-cost Fe-bearing PM Ti alloys permits the achievement of fully dense materials due to the sealing of the residual porosity left by the sintering process via diffusional creep. The vacuum sintered, forged or extruded low-cost Fe-bearing PM Ti alloys have a better overall compromise of tensile properties (UTS vs elongation, Fig. 6c) in comparison with the Ti-6Al-4V processed under the same manufacturing conditions [34]. The higher ductility of the Fe-bearing alloys means, for the same processing temperature, that the material deforms more, resulting, for example, in longer extruded bars. Conversely, this also means lower processing temperatures can be used for the hot deformation of low-cost Fe-bearing PM Ti alloys.

"Regarding the use of alternative sintering techniques, one under development is reactive induction sintering and its applicability has been studied with regard to the BE Ti-5Al-2.5Fe alloy..."

Selection of the correct amount of β eutectoid stabilisers as alloying elements in Ti and appropriate heat treatment procedures provides, through the co-precipitation of α-Ti and TiFe via slow bainitic decomposition, the possibility to create nanostructured low-cost Fe-bearing PM Ti alloys with ultrafine microstructures, achieving comparable or higher hardness values with respect to much more heavily alloyed and costly competitor Ti alloys [35]. In particular, the Fe content has to be greater than 4 wt.% and the alloy is subjected to different ageing conditions after being quenched from the β field for microfeatures and properties tailoring, as demonstrated, the variation of hardness (Fig. 6d).

Manufacturing enhancement

PM Ti alloys are commonly vacuum sintered in batches in the 1200-1400°C temperature range, with long dwell times of 1-4 h, aiming to control the amount of interstitial elements (i.e. oxygen, nitrogen, carbon and hydrogen), the excessive presence of which will significantly embrittle the material. Such manufacturing cycles are lengthy, costly, energy intensive, and negatively affect the performance of the sintered PM alloy, as they induce significant coarsening of the microstructural features. Our effort is therefore focused on finding faster, more efficient and reliable heating techniques, rather than vacuum sintering, for lowering the production cost (e.g. short processing time) and limiting grain growth. The two main initiatives under investigation are the development of alternative sintering techniques and manufacturing optimisation developing deformation mechanism maps.

Alternative sintering techniques

A significant portion of the production cost of PM Ti components derives from the use of standard electric resistance vacuum sintering furnaces, where heat is transferred via radiation, convection and conduction for their consolidation via sintering. More economically efficient methods should then be investigated, aiming to reduce the production cost. Induction heating is a very effective heating method for conductive materials as the heat is generated by electromagnetic induction, through heat generated in the object by eddy currents, directly into the conductive material, saving time and heat losses. High-frequency induction

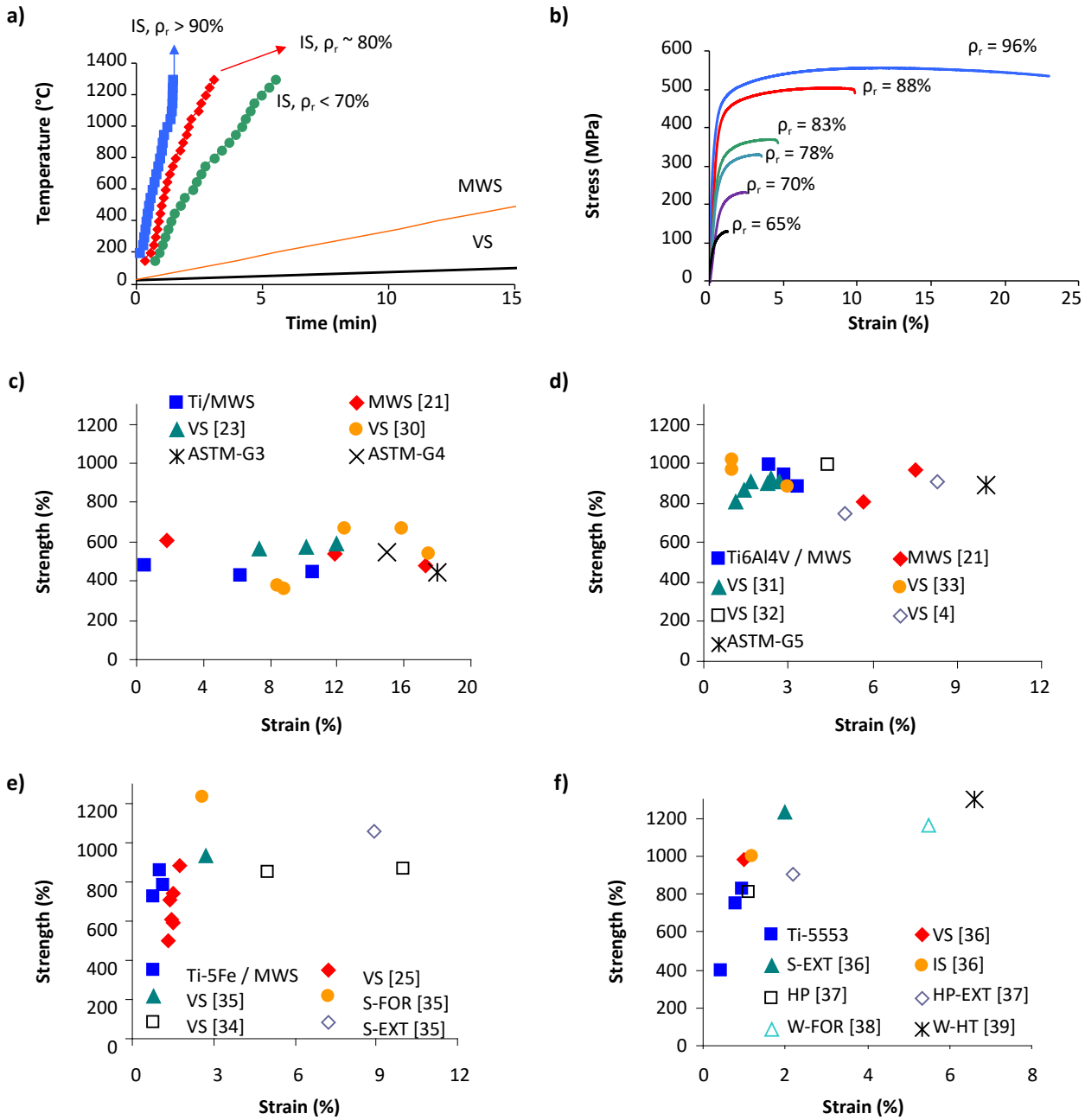


Fig. 7 Representative results for the processing of PM Ti alloys via alternative sintering techniques: a) comparison of the heating rate (legend: IS - Induction Sintering, MWS - Microwave Sintering, VS - Vacuum Sintering, ρ_r = relative density) (adapted from [37]), b) stress-strain curves of Ti powder compacts induction sintered at 1300°C without holding time (adapted from [37]), and c-f) variation of the mechanical properties of microwave sintered blended elemental Ti alloys (note: the reader is referred to [38] for the original legends) (Courtesy Elsevier)

heating is commonly used for metal casting and heat treating in the steel industry, due to the ability to achieve fast heating rates and the relatively simple equipment setup. The combination of fast heating rates and short processing times is expected to lead to fine microstructures with improved mechanical properties [36].

Ti-based powder compacts can be heated up to approximately 1400°C, where the effective heating rate strongly depends on the green density. This is because both the thermal capacity of the powder compact and the heat transferability are influenced by the total amount of porosity, as can be seen in Fig. 7a), because the air trapped between the powder particle acts as an insulator [37]. As expected from classical sintering theory, for comparable sintering conditions, powder compacts with higher green density reach higher values of relative density and mechanical properties, demonstrated by the stress-strain behaviour of induction sintered Ti

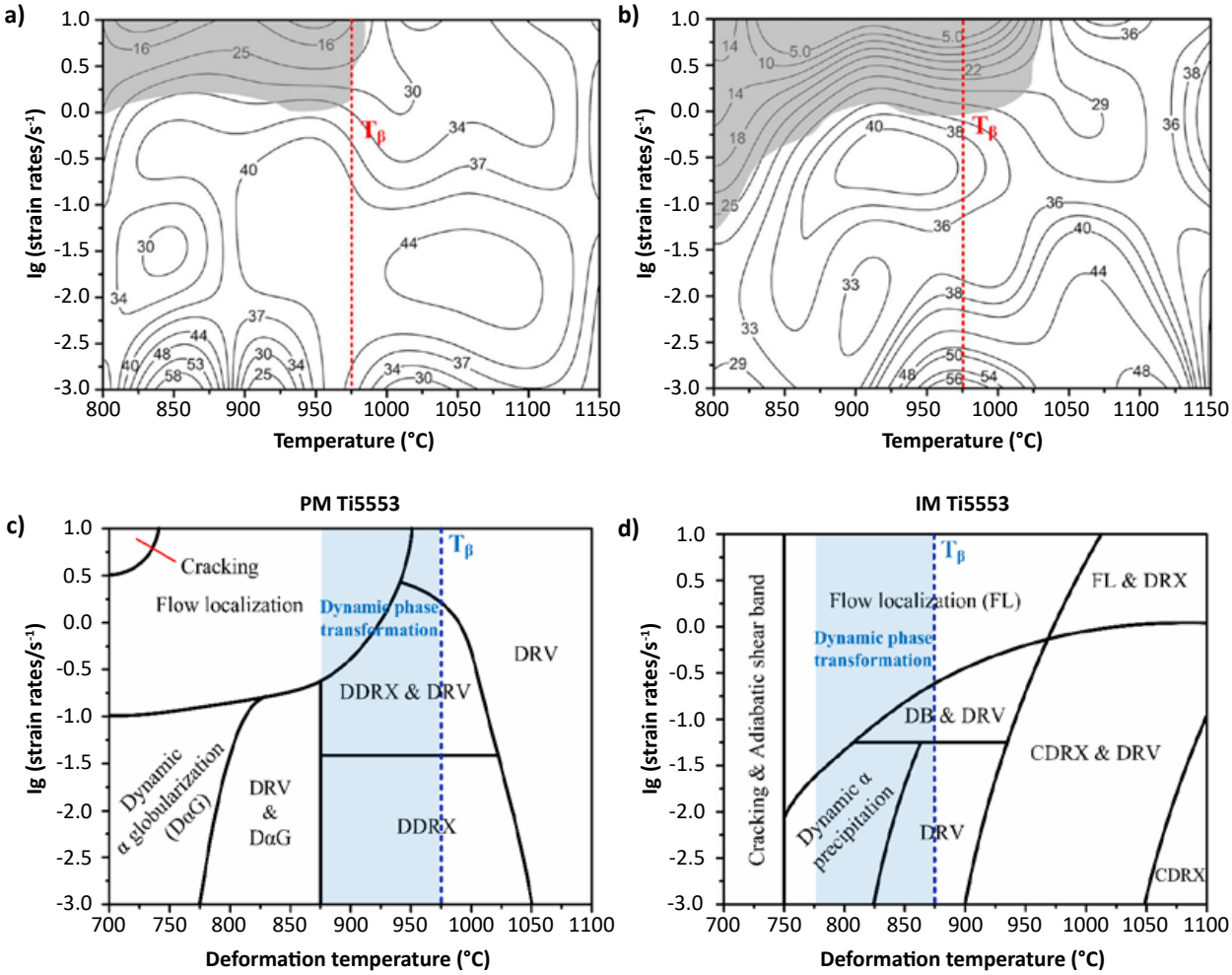


Fig. 8 Representative results for manufacturing optimisation through the generation of hot deformation processing maps: a) PM Ti5553 deformed at true strain of 0.7 [39], b) PM Ti5553 deformed at true strain of 1.2 [39], c) hot deformation mechanisms map of the PM Ti5553 alloy [40], and d) hot deformation mechanisms map of the IM Ti5553 alloy [40] (Courtesy Elsevier)

samples shown in Fig. 7b). With the right combinations of parameters, including relative density (~ 90%), sintering temperature (≥ 1000°C) and dwell time at maximum temperature (≥ 0 s), the induction sintered Ti compacts have mechanical properties comparable with those of HDH Ti compacts conventionally processed via vacuum sintering (UTS = 580±15 and ε ~ 10% [7]) and wrought CP-Ti grade 4 (UTS = 550 MPa and ε = 15% [3]).

In recent years, microwave sintering has been investigated and proposed as an alternative sintering technique to speed up the sintering process of PM Ti alloys. It is worth mentioning that metals are reflectors of microwave radiation, at least at room temperature, but powder compacts are responsive to such radiation, because of the oxygen-rich layer present in the powder particle. This superficial oxide layer and the porosity typical of green compacts increase microwave radiation coupling, allowing the transfer of energy directly into the material and decreasing the overall heating time. The use of a microwave susceptor like SiC (i.e. hybrid microwave sintering) is strongly recommended to guarantee controllable and reliable heating of the Ti compacts. Literature on the subject is, however, limited and performed on relatively small volumes of material, generally below 100 g. Our initiatives are therefore around processing BE PM Ti alloys (both lean and heavily alloyed) to understand the evolution of the microstructure and the variation of the mechanical properties with the sintering parameters and to demonstrate the feasibility of using microwave sintering to manufacture industrially relevant quantities of BE PM Ti alloys.

It is found that fairly large Ti products, in the range of 500 g, can be successfully consolidated via hybrid microwave sintering, using shorter cycles, derived by faster heating rates (see Fig. 7a), and shorter dwell times, but no accelerated sintering is actually apparent in the material. As a general recommendation, higher sintering temperatures and/or longer sintering times are required for more heavily alloyed

systems such as Ti5553, especially if refractory metals are present in the chemical composition, in order to achieve a homogeneous distribution of the alloying elements and proper sintering of the material [38]. As reported in Fig. 7, the mechanical properties of the microwave sintered alloys are similar to those of wrought and vacuum sintered PM alloys, in the case of wrought-equivalent compositions (i.e. Ti and Ti-6Al-4V, Fig. 7c and Fig. 7d, respectively), and, generally, comparable or lower for low-cost Fe-bearing PM Ti alloys and heavily alloyed Ti alloys (i.e. Ti-5Fe and Ti5553, Fig. 7d and Fig. 7f, respectively).

Manufacturing optimisation

Hot workability of metals strongly depends on the capability to plastically deform without cracking or fracturing and/or displaying flow instability (primarily occurring via adiabatic shear bands and localised plastic flow) to guarantee the integrity of the material. This is a challenge for hard-to-deform Ti alloys, especially near β Ti alloys which are very sensitive to processing variables. The generation of activation energy maps and hot processing maps, via the dynamic material model from thermal physical processing simulation, is a powerful tool to understand the hot deformation behaviour of an alloy. Flow stress usually increases rapidly to the peak stress, but then gradually decreases if the temperature and the strain rate are high enough meaning that, after the initial work hardening that occurs as soon the load is applied, dynamic recovery or recrystallisation occurs within the material. Flow stress is then minimised by increasing the hot deformation temperature and reducing the strain rate. After TDM, PM alloys are generally characterised by finer microstructures, in comparison with IM alloys, and some fine residual pores can still be present, with both of these factors affecting the dynamic response of the alloy.

A direct comparison of the hot deformation maps was done, considering a highly-alloyed near-β Ti alloy where the Ti5553 alloy was manufactured via hot pressing a BE alloy made by mixing HDH Ti powder with 35Al-65V, 15Al-85Mo and 30Al-70Cr master alloys. The PM Ti5553 alloy has better hot workability, with a large crack-free processing window, and lower deformation resistance than IM Ti5553 alloy (Fig. 8). However, in contrast to IM Ti5553 alloy, brittle cleavage fracture rather than ductile dimple cracking is predominant for PM Ti5553 alloy [39]. The PM Ti5553 alloy has also higher flow stability during hot deformation, with high strain rates as highlighted by the presence of less discontinuous yielding phenomena associated with the sudden activation of dislocations piled-up at grain boundaries.

From the comparison of the hot deformation maps, reporting the different mechanisms operating in the PM Ti5553 alloy and IM Ti5553 alloy (Figs. 8c and 8d), it can be seen that the IM Ti5553 alloy has a much larger flow instability domain (including cracking, adiabatic shearing and flow localisation) and much more pronounced microstructural changes occur in the PM Ti5553 alloy (i.e. dynamic α globularisation and coarsening, extensive dynamic full recrystallisation). The wider range of temperature/strain rate combinations that can be used to safely hot deform the PM Ti5553 alloy, and consequently the different recovery and recrystallisation mechanisms that can be activated, are a consequence of the refined microstructure and the higher oxygen content (which significantly affects the β transus) of the PM Ti5553 alloy [40].

Concluding remarks

Strategies and initiatives for the production of cost-affordable Powder Metallurgy Ti alloys include the design and processing of cost-effective chemical compositions and the investigation of the associated manufacturing processes. Specifically, the blended elemental approach allows the flexibility of targeting the production of wrought-equivalent compositions such as the Ti-6Al-4V alloy, regardless of whether they are lean or highly alloyed alloys, as well as the development of non-standard compositions such as low-cost Fe-bearing PM Ti alloys. Alternative sintering techniques and optimisation of the manufacturing route via the generation of hot deformation maps permit, respectively, shortening of the manufacturing cycle (with the associated reduction of the overall cost) and understanding the differences, in terms of metallurgical mechanisms operating within the materials, for the correct selection of the appropriate processing parameters depending on the complementing manufacturing method used. Ti alloys spanning from α, α+β and β, can be successfully manufactured via the simple press and sinter Powder Metallurgy approach, and thermomechanical powder processing can be considered to enhance the performance of cost-effective PM Ti alloys, especially if dynamic-loading properties such as fatigue and fracture toughness are of concern. Characterisation of specific *in operando* conditions

"Strategies and initiatives for the production of cost-affordable Powder Metallurgy Ti alloys include the design and processing of cost-effective chemical compositions and the investigation of the associated manufacturing processes..."

should be expanded to guide the design of pilot-scale trials for the validation and industrial implementation of cost-affordable Powder Metallurgy Ti alloys.

Acknowledgements

L Bolzoni would like to acknowledge that the research leading to these results has been funded by the New Zealand Ministry of Business, Innovation and Employment (MBIE) through the TiTeNZ (Titanium Technologies New Zealand - UOWX1402) research contract. L Bolzoni would like to thank Dr Fei Yang, Dr Stiliana Raynova, Dr Mingtu Jia, Carlos Romero and Qingyang Zhao for their scientific and technical contributions.

Author

Dr Leandro Bolzoni
School of Engineering,
The University of Waikato,
Private Bag 3105, Hamilton 3240,
New Zealand
bolzoni.leandro@gmail.com
Tel: +64 7 837 9381
Fax: +64 7 838 4835

Dr Leandro Bolzoni profile:
http://bit.ly/LeandroBolzoni

Titanium Technologies New Zealand:
https://titenz.co.nz/

Researchgate project log:
http://bit.ly/TiTeNZ

References

[1] G. Lütjering, J.C. Williams, Titanium: Engineering Materials and Processes, 1st ed., Springer, Manchester, UK, 2003.

[2] C. Leyens, M. Peters, Titanium and Titanium Alloys. Fundamentals and Applications, Wiley-VCH, Köln, Germany, 2003.

[3] R. Boyer, G. Welsch, E.W. Collings, Materials Properties Handbook: Titanium Alloys, in: A. International (Ed.), Ohio, USA, 1998.

[4] F.H. Froes, M.N. Gungor, M.A. Imam, Cost-affordable Titanium: The Component Fabrication Perspective, *JOM*, 59 (2007) 28-31.

[5] A. Amherd Hidalgo, R. Frykholm, T. Ebel, F. Pyczak, Powder Metallurgy Strategies to Improve Properties and Processing of Titanium Alloys: A Review, *Advanced Engineering Materials*, 19 (2017) 1600743.

[6] L. Bolzoni, P.G. Esteban, E.M. Ruiz-Navas, E. Gordo, Mechanical Behaviour of Pressed and Sintered Titanium Alloys Obtained from Prealloyed and Blended Elemental Powders, *Journal of the Mechanical Behavior of Biomedical Materials*, 14 (2012) 29-38.

[7] L. Bolzoni, E.M. Ruiz-Navas, E. Gordo, Powder Metallurgy CP-Ti Performances: Hydride-dehydride vs. sponge, *Materials and Design*, 60 (2014) 226-232.

[8] L. Bolzoni, E.M. Ruiz-Navas, E. Gordo, Feasibility Study of the Production of Biomedical Ti-6Al-4V Alloy by Powder Metallurgy, *Materials Science and Engineering C*, 49 (2015) 400-407.

[9] K. Songsiri, A. Manonukul, P. Chalermkarnnon, H. Nakayama, M. Fujiwara, Effects of Sintering Temperature and Sintering Time on Mechanical and Impact Properties of Injection Moulded Ti-6Al-4V Employing Prealloyed and Mixed Powders, Advances in Powder Metallurgy & Particulate Materials, MPIF, Washington, D.C. - U.S.A., 2008, pp. 175-182.

[10] O.M. Ferri, T. Ebel, R. Bormann, High Cycle Fatigue Behaviour of Ti-6Al-4V Fabricated by Metal Injection Moulding Technology, *Materials Science and Engineering: A*, 504 (2009) 107-113.

[11] M. Holm, T. Ebel, M. Dahms, Investigations on Ti-6Al-4V with Gadolinium Addition Fabricated by Metal Injection Moulding, *Materials and Design*, 51 (2013) 943-948.

[12] K.T. Kim, H.C. Yang, Densification Behavior of Titanium Alloy Powder during Hot Pressing, *Materials Science and Engineering A*, 313 (2001) 46-52.

[13] L. Bolzoni, E.M. Ruiz-Navas, E. Gordo, Influence of Vacuum Hot-pressing Temperature on the Microstructure and Mechanical Properties

of Ti-3Al-2.5V Alloy Obtained by Blended Elemental and Master Alloy Addition Powders, *Materials Chemistry and Physics*, 137 (2012) 608-616.

[14] L. Bolzoni, I. Montealegre Meléndez, E.M. Ruiz-Navas, E. Gordo, Microstructural Evolution and Mechanical Properties of the Ti-6Al-4V Alloy Produced by Vacuum Hot-pressing, *Materials Science and Engineering A*, 546 (2012) 189-197.

[15] K.T. Kim, H.C. Yang, Densification Behavior of Titanium Alloy Powder under Hot Isostatic Pressing, *Powder Metallurgy*, 44 (2001) 41-47.

[16] H.K. Rafi, N.V. Karthik, H. Gong, T.L. Starr, B.E. Stucker, Microstructures and Mechanical Properties of Ti6Al4V Parts Fabricated by Selective Laser Melting and Electron Beam Melting, *Journal of Materials Engineering and Performance*, 22 (2013) 3872-3883.

[17] X. Huang, L. Lang, G. Wang, Effect of HIP Post-treatment on the HIPed Ti6Al4V Powder Compacts, *Powder Metallurgy*, 62 (2019) 8-14.

[18] S. Leuders, M. Thöne, A. Riemer, T. Niendorf, T. Tröster, H.A. Richard, H.J. Maier, On the Mechanical Behaviour of Titanium Alloy TiAl6V4 Manufactured by Selective Laser Melting: Fatigue Resistance and Crack Growth Performance, *International Journal of Fatigue*, 48 (2013) 300-307.

[19] E. Brandl, C. Leyens, F. Palm, Mechanical Properties of Additive Manufactured Ti-6Al-4V Using Wire and Powder Based Processes, *IOP Conference Series: Materials Science and Engineering*, 26 (2011) 012004.

[20] C. Romero, F. Yang, L. Bolzoni, Fatigue and Fracture Properties of Ti Alloys from Powder-based Processes - A Review, *International Journal of Fatigue*, 117 (2018) 407-419.

[21] H. Wang, Z.Z. Fang, P. Sun, A Critical Review of Mechanical Properties of Powder Metallurgy Titanium, *International Journal of Powder Metallurgy*, 46 (2010) 45-57.

[22] M. Jia, C. Blanchard, L. Bolzoni, Microstructure and Mechanical Properties of Ti-5Al-2.5Fe Alloy Produced by Powder Forging, *Key Engineering Materials*, 770 (2018) 39-44.

[23] E. Gordo, A. Garcia-Casas, A. Montero, A. Jiménez-Morales, B. Gabbitas, L. Bolzoni, Influence of PM Processing Method on the Corrosion and Oxidation Behaviour of a Low-cost Ti-Fe Alloy, Proceedings Euro PM 2017: International Powder Metallurgy Congress and Exhibition, Lightweight Materials (2017) ep17-3684146.

[24] J. Lu, Y. Zhao, H. Niu, Y. Zhang, Y. Du, W. Zhang, W. Huo, Electrochemical Corrosion Behavior and Elasticity Properties of Ti-6Al-xFe Alloys for Biomedical Applications, *Materials Science and Engineering: C*, 62 (2016) 36-44.

[25] L. Bolzoni, Low-cost Fe-bearing Powder Metallurgy Ti Alloys, *Metal Powder Report*, https://doi.org/10.1016/j.mprp.2019.01.007 (2019).

[26] H. Nakajima, K. Yusa, Y. Kondo, Diffusion of Iron in a Diluted [Alpha]-Ti-Fe Alloy, *Scripta Materialia*, 34 (1996) 249-253.

[27] H. Nakajima, S. Ohshida, K. Nonaka, Y. Yoshida, F.E. Fujita, Diffusion of Iron in [Beta] Ti-Fe Alloys, *Scripta Materialia*, 34 (1996) 949-953.

[28] Y.A. Shevchuk, Interdiffusion in the β Phases of the Ti-Ni and Ti-Fe Systems, *Inorganic Materials*, 40 (2004) 376-379.

[29] J.L. Murray, Phase Diagrams of Binary Titanium Alloys, 1st ed., ASM International, 1987.

[30] L. Bolzoni, E. Herraiz, E.M. Ruiz-Navas, E. Gordo, Study of the Properties of Low-cost Powder Metallurgy Titanium Alloys by 430 Stainless Steel Addition, *Materials and Design*, 60 (2014) 628-636.

[31] L. Bolzoni, E.M. Ruiz-Navas, E. Gordo, Quantifying the Properties of Low-cost Powder Metallurgy Titanium Alloys, *Materials Science and Engineering: A*, 687 (2017) 47-53.

[32] L. Bolzoni, E.M. Ruiz-Navas, E. Gordo, Understanding the Properties of Low-cost Iron-containing Powder Metallurgy Titanium Alloys, *Materials & Design*, 110 (2016) 317-323.

[33] M.T. Jia, B. Gabbitas, L. Bolzoni, Evaluation of Reactive Induction Sintering as a Manufacturing Route for Blended Elemental Ti-5Al-2.5Fe Alloy, *Journal of Materials Processing Technology*, 255 (2018) 611-620.

[34] S. Raynova, B. Gabbitas, L. Bolzoni, F. Yang, Development of Low Cost PM Ti Alloys by Thermomechanical Processing of Powder Blends, *Key Engineering Materials*, 704 (2016) 378-387.

[35] C. Romero, S. Raynova, F. Yang, L. Bolzoni, Ultrafine Microstructures in Eutectoid Element Bearing Low-cost Ti-Fe Alloys Enabled by Slow Bainite Formation, *Journal of Alloys and Compounds*, 769 (2018) 226-232.

[36] C. Çivi, E. Atik, The Effect of Inductive Sintering to Iron Based Powder Metal Parts, *Journal of Alloys and Compounds*, 753 (2018) 517-524.

[37] S. Raynova, Y. Collas, F. Yang, L. Bolzoni, The Effect of the Green Density on the Properties of Powder Metallurgy Ti Sintered by High Frequency Induction Heating, *Applied Mechanics and Materials*, 884 (2018) 43-48.

[38] S. Raynova, M.A. Imam, F. Yang, L. Bolzoni, Hybrid Microwave Sintering of Blended Elemental Ti Alloys, *Journal of Manufacturing Processes*, 39 (2019) 52-57.

[39] Q.Y. Zhao, F. Yang, R. Torrens, L. Bolzoni, Evaluation of the Hot Workability and Deformation Mechanisms for a Metastable Beta Titanium Alloy Prepared from Powder, *Materials Characterization*, 149 (2019) 226-238.

[40] Q. Zhao, F. Yang, R. Torrens, L. Bolzoni, Comparison of Hot Deformation Behaviour and Microstructural Evolution for Ti-5Al-5V-5Mo-3Cr Alloys Prepared by Powder Metallurgy and Ingot Metallurgy Approaches, *Materials & Design*, 169 (2019) 107682.

Nichols Portland: The world's first manufacturer of gerotors continues to innovate

As the world's first manufacturer of gerotors and gerotor pumps, Nichols Portland has more than 85 years of continuous experience in the manufacturing, design, application, testing and validation of these products. Although Nichols Portland is known globally for its fluid transfer technology, the company also supports industries with a range of PM components. In this report, Randy Lessard, the company's VP / General Manager, reviews the history of Nichols Portland and discusses its commitment to producing precision PM components.

Beginning in the late 1920s, the W.H. Nichols Company became the world's first manufacturer of gerotors and gerotor pumps. Working in partnership with the inventor of the gerotor, W.H. Nichols patented the first equipment capable of commercially producing the highly complicated gear shape. The company then put its equipment to use producing the world's first gerotor pump for an oil burner application. The pioneering spirit that introduced this product to the world is still alive and well, and for more than 85 years Nichols has been promoting and innovating the design of gerotors and gerotor pumps in everything from foam packaging systems to automotive traction control systems.

At the heart of all this is said to be a genuine passion for its customers, their products, and the markets they serve. For more than thirty years Nichols Portland has had product development and product validation teams focused exclusively on helping its customers develop and validate their products. To that end, the company has developed testing facilities and engineering capabilities to the point where Nichols Portland can conduct most of the pump validation testing required by the major OEMs in-house.

Fig. 1 The Nichols Portland facility in Portland, Maine, USA

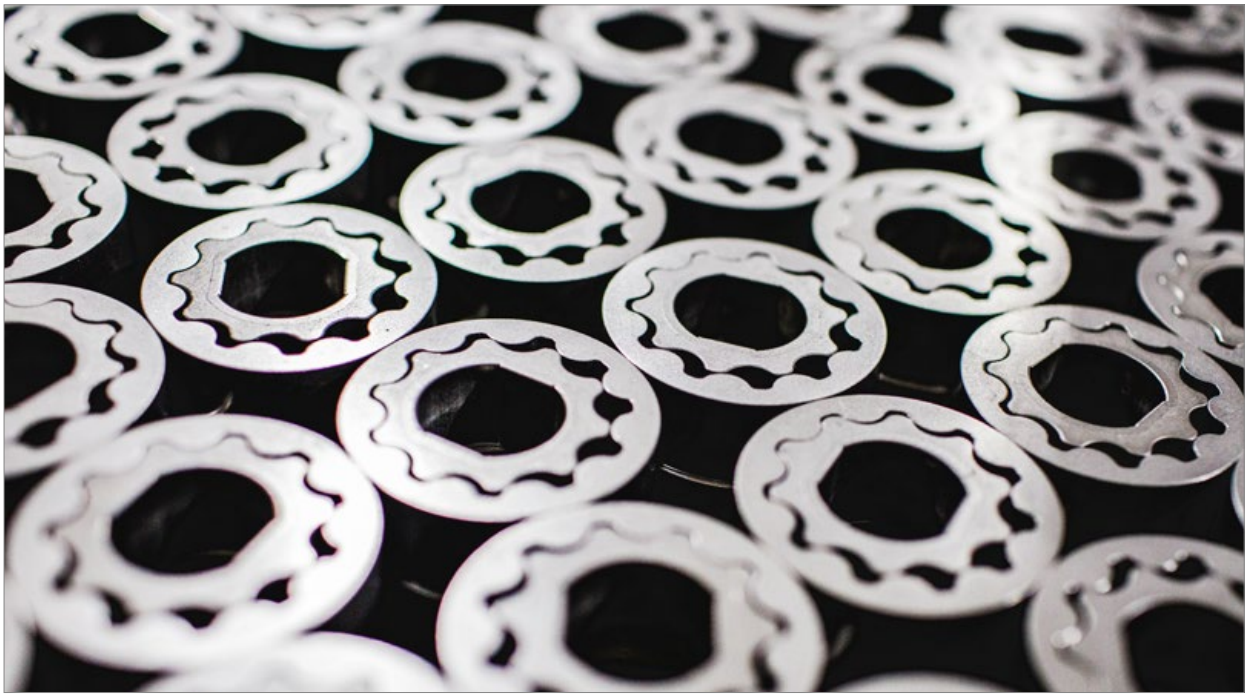


Fig. 2 Production of commercial PM gerotors began in the early 1980s

The company's interest in Powder Metallurgy dates to the early 1970s, when it recognised PM as a critical enabler in expanding the addressable market for its products beyond what was possible with traditional billet manufacturing processes. By the early 1980s, the company was awarded its first PM gerotor for a high-volume engine lubrication application. The decision to expand its product offerings to include PM manufacturing began a period of expansion and growth that continues to this day.

When Nichols was purchased by Parker Hannifin in 1984, Nichols Portland had divisions in Waltham, Massachusetts, Sturtevant, Wisconsin, Gray and Portland, Maine. While all the other locations focused on manufacturing pumps, the Portland Maine facility became the corporate home for gerotor manufacturing. The facility has been expanded many times over the years to support the inclusion of PM manufacturing and the global demand for PM gerotors in automotive applications. Nichols Portland is the only remaining entity carrying the Nichols name, as the other divisions were absorbed by other Parker operations.

A modern PM manufacturing facility

Today, Nichols Portland is a manufacturer and global supplier of Powder Metallurgy components, billet components, and niche pump assemblies for a wide range of platforms and applications. With two manufacturing facilities in Portland and South Portland, Maine, Nichols is continuing to expand into new markets and new applications.

With twenty-eight compacting and sizing presses ranging in size from 20 to 750 tons, and ten sintering furnaces, the company has the capability to produce a wide variety of shapes, sizes and material properties tailored to customer needs. In the coming months, NP will add four additional presses and another furnace. In addition to a state-of-the-art manufacturing line, the company offers:

- A large catalogue of standard product offerings to help smaller-sized customers find a product that meets their application requirements
- A team of dedicated application engineers which works with customers to design customised solutions to optimise application performance
- An advanced engineering team which provides computer-aided design and simulation support, utilising lessons learned from thirty-years of internally developed best pump practices
- A dedicated team to support its customers' product validation needs
- In-house tool and gage design and build, custom powder blending, heat treatment
- Automated part transfer, in-line crack detection and inspection, and end-of-line testing.

"Our business, originated in machined steel and cast-iron pump components, established a solid foundation for the extensive secondary machining capabilities that exist today," stated Rick Scott, Director of Engineering.

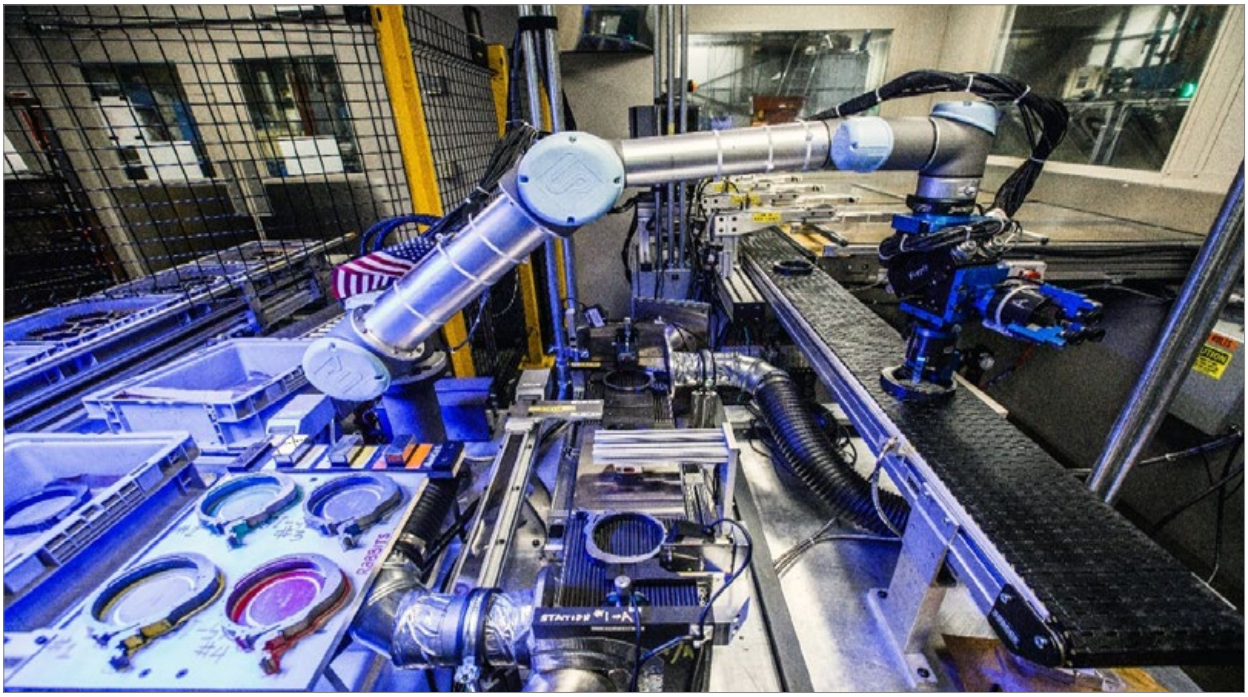


Fig. 3 Automation in the PM production line helps lower manufacturing time and increase speed to market

In-house secondary operations include heat treatment, surface treatment (including steam treatment and phosphate), CNC mill, turn, grinding, broaching, hobbing, hone and lapping.

"Having these in-house capabilities provides us with several competitive advantages, including a quick response time, complete dimensional control of the final product, and a cost-effective supply chain," added Stephen Madill, VP Sales & Marketing.

Working with its customers

Nichols Portland learned long ago that in order to be successful in the market place, it needed to provide its customers with system level solutions. For Nichols Portland, this means understanding the customer's applications to the point where they can act as a development partner.

"Our strategy is simple and steers our customers clear of any design-related problems. Our teams' extensive knowledge and experience allows us to see red flags before they occur, resulting in a successful product for our customers," commented Glenn Mann, Product Engineering Manager.

Nichols Portland typically works with its customers during the advanced design stages of a programme. Its goal is to help customers avoid design related issues. This reduces the problem-related costs that are usually

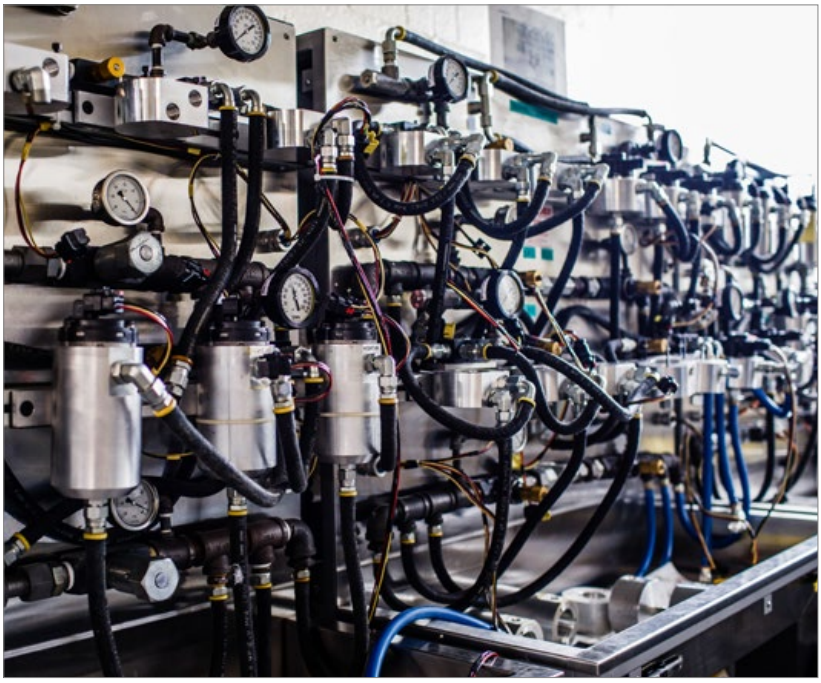


Fig. 4 Pumps are tested at Nichols Portland to ensure that components meet the high quality and performance expected

Fig. 5 Nichols Portland manufactures a wide range of PM components to high tolerances. Shown top is a VDP rotor, middle is a spur gear, bottom left a steel gerotor, bottom right a hubbed steam treated gerotor

not discovered until the testing and validation stages. The company does this by leveraging the accumulated experience of its application team, several of whom have been with Nichols Portland for more than thirty years. It has a large library of test data from benchmarking commercially available products in the markets it serves (Fig. 4). Quite often, that includes designing test fixtures and testing pumps in order to quantify performance, and the contribution of specific features to that performance. Nichols Portland's reports, which follow several SAE and ISO testing procedures, generally total more than one hundred pages.

Key products and applications

The products Nichols Portland produces can generally be classified into one of the following categories:

- Positive displacement pump components (gerotor, spur gear, crescent, etc.)
- Variable displacement pump components (bore rings, vane rotors)
- Structural components (plates, eccentric rings, etc.)
- Non-pump components (timing gears, speed sensors, VVT components, etc.)

Niche pumps

The company has design and simulation capabilities, and a library of test and analysis reports, for all types of pumps. "We also produce pumps for niche applications. Doing so helps customers who might otherwise be underserved by the market, and it provides us with a deeper understanding of the day to day issues customers go through. These experiences help Nichols Portland better serve all our customers," added Manasi Joshi Lakatos, Business Development Manager.

Gerotors

The word 'gerotor' was coined by the inventor of the gerotor, Myron Hill, and is a merger of the two words, GEnerated ROTOR (GE-ROTOR, or Gerotor). Made up of two components, a gerotor is a positive displacement device consisting of an inner and outer rotor. In most applications, the rotating action of the outer gear will trace the profile of the much more complicated inner gear. When done correctly, the two gears will roll past one another with very little sliding friction. This is one of the reasons that gerotors are known for their long life and smooth operating characteristics.

As the rotors rotate about their respective axes, fluid is drawn into an enlarging chamber that is created between the inner and outer rotor. As rotation continues, the chamber will reach a maximum volume which defines the displacement of the rotor set. As rotation continues, volume decreases, forcing fluid out of the rotors. This process occurs for each pumping chamber, resulting in a smooth pumping action.

Other products

Although Nichols Portland is best known for its gerotors, the company also makes PM components for just about every positive and variable displacement pump used in the automotive and on/off-highway industries (Fig. 5).

A recent success was the development of a PM rotor vane used in an high-performance automotive engine.

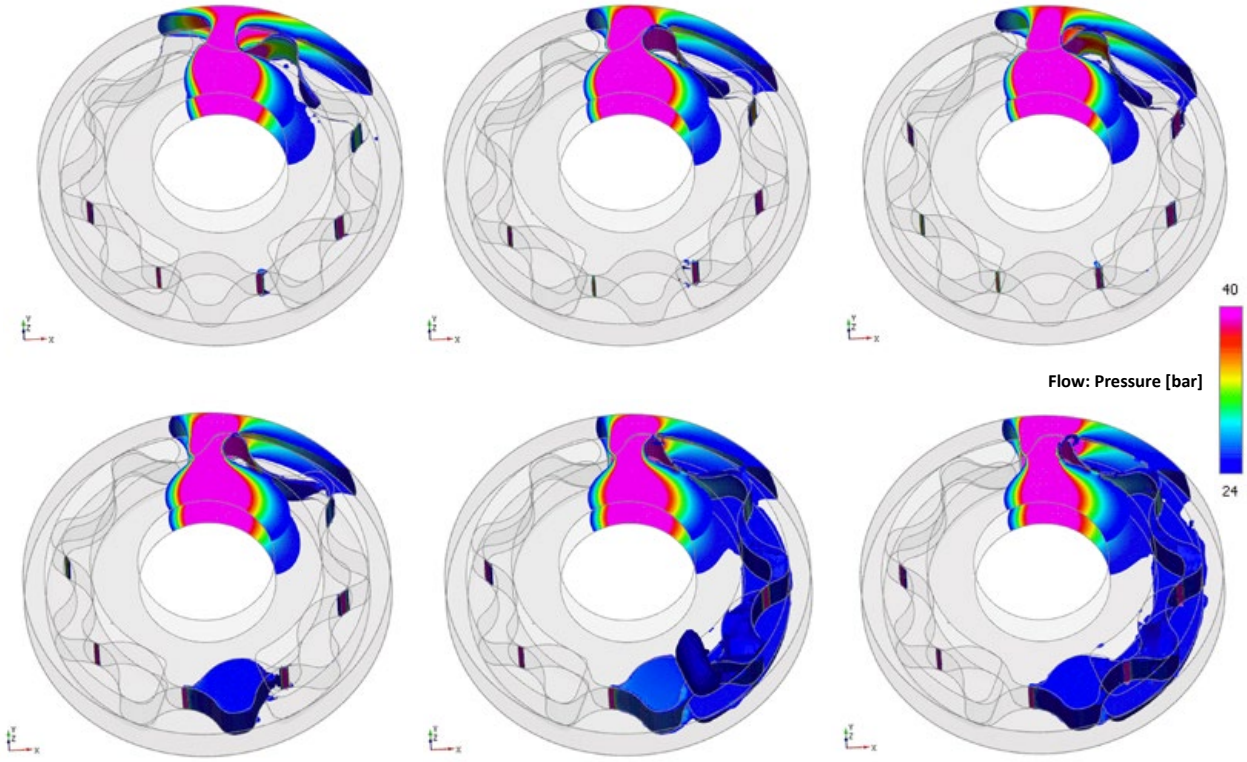


Fig. 6 CFD is used to identify the high pressure zone in this gerotor simulation

The company recently received a Metal Powder Industries Federation (MPIF) award of Distinction for this part in the association's annual PM Design Excellence Awards competition. The rotor vane is discussed in more detail on the following pages.

Improving products, supporting customers

Design support

Nichols Portland offers its customers two levels of application support; standard and advanced. Standard support is free of charge and includes recommendations for gear geometry, material selection, fluid porting, and internal pump clearances. The company also provides analysis of gear stresses, flow ripple, and power draw as a function of temperature, internal clearances, speed and fluid type.

Advanced support services include finite element analysis (FEA), computational fluid dynamics (CFD), and physical testing. FEA analysis can be conducted on either the gear or the pump housing and can be used to predict how both can be expected to react to real-world forces such as fluid pressure and mechanically-induced vibration. CFD is a branch of fluid mechanics that uses numerical analysis and data structures to analyse and solve complex problems related to fluid flow (Fig. 6). It enables the simulation of the free-stream flow of the fluid, including the entrained oil vapour and air, allowing users to predict aeration, cavitation, temperature rise, cooling capabilities, and valve resonance.

Over the years, many major automotive OEMs from around the world have contracted Nichols Portland's

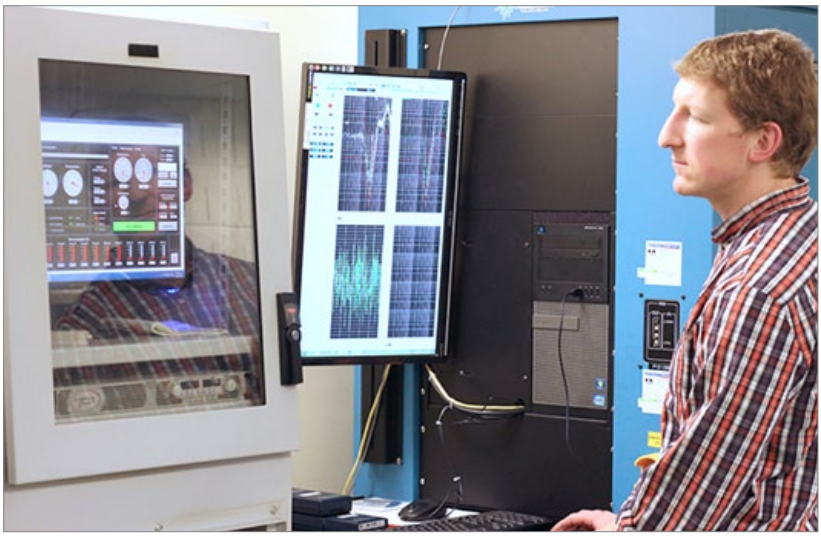


Fig. 7 Nichols Portland has a wide range of in-house testing and analysis available to ensure components meet customer requirements

Fig. 8 The vane rotor is used in an engine lubrication system. Of importance is the accuracy of the rotor radial dimensions, ID spline and vane slot features

testing services for both advanced work and product development and validation testing. The company has developed the capabilities to conduct nearly every testing requirement of every major OEM. That includes valve and spring endurance testing, contamination resistance, thermal cycle, vibration, performance, and durability testing (Fig. 7).

Award winning components

As previously mentioned, a recent Award of Distinction in the 2019 MPIF Powder Metallurgy Design Excellence Awards was presented to Nichols Portland in the Automotive-Engine category for conventional PM components. The winning part was a vane rotor used in a lubrication pump for a high-performance engine (Fig. 8).

"The customer needed a very compressed product development timeline and approached Nichols Portland because of our reputation for producing consistent quality in a high tolerance part," added Rick Scott.

The rotor is a two-level component that must achieve tight tolerances on several features critical to the performance of the pump. In order to minimise the requirements for secondary machining, the tooling and process were targeted to minimise manufacturing variation. Process steps include compact, sinter, size, thickness grinding, deburring and cleaning.

The product application requires high accuracy of the rotor radial dimensions, the ID spline and vane slot features in order to reduce the pump's internal leakages and meet the long-life requirements.

High principle stresses from the compact pressures required the use of FEA analysis to refine the tooling strategy and construction methods in order to avoid premature tooling compaction failures. "In order to meet the critical spline perpendicularity requirements, we leveraged our machining knowledge to properly balance part holding during the grinding operation with our compaction control strategies," continued Scott.

The requirements for material projections (burrs) and cleanliness also necessitated special care during the tool cleaning and sharpening process in order to ensure burr free features during compaction.

The part application is highly sensitive to process variation and therefore has multiple features requiring critical process control. Rigorous application of the PFMEA process resulted in a carefully designed manufacturing process which allowed Nichols to achieve the Cpk requirements for the part.

"In order to be considered a success, we needed to satisfy multiple objectives including technical, manufacturing, and commercial feasibility. Our development of a highly capable and stable manufacturing process allowed us to achieve the tight manufacturing tolerances for most features in our PM processes. This allowed the customer to realise the full advantages of PM in driving their programme to a successful market introduction," stated Scott.

Case study: Niche Pump Assembly

This pump assembly was custom-designed by Nichols Portland. It is used in a foam packaging application.

The components require extremely tight positional and size tolerances to enable precise flow output at very high pressures and with little variation.

The assembly includes an application-specific gerotor, purposely designed for low rolling stresses. The entire pump also has surface treatments which support long life and robust journal bearings.

Case study: Niche Pump Assembly

This pump assembly was custom designed by Nichols Portland for use in the cooling of power electronics where extremely long-life if a very low lubricity environment is a requirement.

The specified fluid was R134a and R245fa. Flow requirements were 0.25, 0.5, and 2.6-gpm at 50-psig.

The solution included stainless steel spur gears, coated pump surfaces and a brushless DC motor and controller with variable speed control.

Future success

Nichols Portland has evolved many times since the late 1920s and plans to continue to do so. The company's leadership continues to focus on innovation and technology as drivers of success.

"Nichols Portland's utilisation of advanced technologies, such as artificial intelligence, robotics, and vision systems illustrates our vision for the future. Nichols Portland is a great example of bringing additional capabilities to the market, in order to be a solution provider and problem solver for our customers," stated Thomas K Houck, President and CEO of Nichols Portland.

With a reputation for precision components and a commitment to delivering quality in the Powder Metallurgy process chain, the company is looking to build on its position as a leading supplier of fluid transfer devices.

"Our mission is to provide our customers with a positive vendor experience that is unequalled anywhere else in their supply chain. Nichols has been a standard when it comes to fluid transfer technology. Whether it is providing design input, highly precise PM or billet components, or niche pump assemblies, Nichols Portland has a global reputation for excellence. We look forward to utilising those strengths and expanding into adjacent markets in the Powdered Metal and Niche Pump space," concluded Madill.

Contact

Stephen Madill,
VP of Sales & Marketing
Nichols Portland
2400 Congress Street
Portland,
Maine 04102
USA

Tel: +1 207 774 6121
sales@nicholsportland.com
linked-in: Nichols Portland
www.nicholsportland.com

MPIF's 2019 PM Design Excellence Award winning parts highlight wide variety of applications

The winners in the 2019 Powder Metallurgy Design Excellence Awards competition, sponsored by the Metal Powder Industries Federation, were announced during the POWDERMET2019 International Conference on Powder Metallurgy and Particulate Materials, Phoenix, Arizona, USA, June 23–26, 2019. Here, we present the Conventional 'press and sinter' PM components that received either Grand Prizes or Awards of Distinction.

Each year since 1965, the Metal Powder Industries Federation (MPIF) has sponsored a competition where all member companies are invited to submit components that showcase the many possibilities of Powder Metallurgy technology. An expert panel evaluates the entries according to a stringent set of criteria and awards Grand Prizes and Awards of Distinction to winning companies.

According to the MPIF, this year's winners demonstrated outstanding examples of PM's diversity as a manufacturing technology, and highlighted how each winning design uses PM's flexibility to push forward new concepts and process controls. The components are said to demonstrate the capabilities offered by PM in the service of component design for critical applications such as auto engines and transmissions, medical devices, consumer products, hardware and more.

Nine Grand Prizes and seven Awards of Distinction were given in the 2019 awards. Among those, ten awards were given to companies in the conventional press and sinter PM category. Full details of the MIM award winning components will be published in *PIM International* (Vol. 13, No 3).

Grand Prizes

Automotive-Engine: Capstan Inc

A Grand Prize in the Automotive-Engine Category was awarded to Capstan Inc, USA, (Fig. 1) for a compact brushless DC actuator

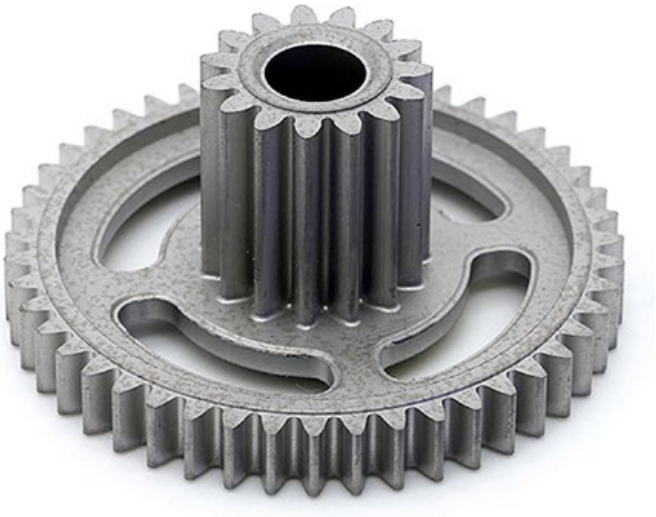


Fig. 1 Capstan Inc, received a Grand Prize for this compact brushless DC actuator gear (Courtesy MPIF)

Fig. 2 This clutch backing plate and pressure apply piston, manufactured by Stackpole, is used in the General Motors 9T50/65 Hydra-Matic transmission (Courtesy MPIF)

gear designed to optimise engine performance and reduce nitrogen oxide emissions for on- and off-road commercial diesel-engine vehicles. Made from 316L, all gear dimensions meet AGMA level 7 requirements. The stainless steel precision gear required unique carbide tooling for compaction.

Capstan principally operates through its three manufacturing locations - Capstan California (Los Angeles), Capstan Atlantic (Boston), and Capstan Mexico (Guadalajara) - with each location specialising in different segments of the PM industry.

www.capstan.com

Fig. 3 These parts form a miniature planetary gear carrier set. Manufactured by ASCO Sintering, the set is used in an irrigation system (Courtesy MPIF)

Automotive-Transmission: Stackpole International

A Grand Prize was awarded to Stackpole International, Canada, in the Automotive-Transmission Category for a clutch backing plate and pressure-apply piston (Fig. 2). Used in the General Motors 9T50/65 Hydra-Matic transmission, these parts form a combined sub-assembly within the transmission, together with a central hub and two roller-bearing races. Compaction of the parts involves the use of multiple element tooling, and a complex die design is needed to form the near-net shape geometry.

With Corporate Services in Ancaster, Ontario, Canada, Stackpole International operates from manufacturing facilities and technical centres throughout North America, Europe and Asia.

www.stackpole.com

Lawn & Garden/Off-Highway: ASCO Sintering Co

A Grand Prize was awarded to ASCO Sintering Co., USA, in the Lawn & Garden/Off-Highway Category for a miniature planetary gear carrier set (Fig. 3). The set is used in a commercial rotary irrigation system. The parts are made from SS-316N1,N2 and compacted to a green density of 6.6 g/cm^3.

ASCO Sintering Co., based in Commerce, California, is an employee-owned company with sales offices in USA, Europe and Africa. The company specialises in the manufacture and design of sintered planetary gear carriers, associated PM gear assemblies, and other precision PM components.

www.ascosintering.com

Industrial Motors/Controls & Hydraulics: ASCO Sintering Co

In the Industrial Motors/Controls & Hydraulics Category, a further Grand Prize was awarded to ASCO Sintering Co. for the spring seat of a hydraulic valve actuator mechanism (Fig. 4). The part is made from SS-316H-20 and is compacted to a green density of 6.5 g/cm^3 prior to sintering.

The five blades of the component are long and too thin to be compacted to net shape directly, so extra material is added in the region of the blades. A low-cost turning operation is needed to achieve the final part geometry.

www.ascosintering.com

Fig. 4 This hydraulic valve actuator, made by ASCO Sintering, is used in a spring seat (Courtesy MPIF)

Awards of Distinction

Automotive-Engine: Catalus Corporation

In the Automotive-Engine Category, an Award of Distinction was given to Catalus Corporation, USA, for an access-hole cover used to transfer collected oil from the crankcase ventilation system at the top of the engine into the engine block (Fig. 5). It had to use an existing bolt pattern and have a low profile to permit clearance to the nearby engine control module. The PM part replaced an assembly of multiple stamped, machined, and drawn components and resulted in a 27% weight saving.

Formally SMC Powder Metallurgy Inc, the company became Catalus Corp. in October 2018. It has production facilities in St. Mary's and Galeton, as well as a dedicated PM research facility, also in Galeton.

www.cataluscorp.com

Fig. 5 Catalus Corporation manufactures this access hole cover, used in the crankcase ventilation system (Courtesy MPIF)

Automotive-Engine: Nichols Portland LLC

Another Award of Distinction in the Automotive-Engine Category was won by Nichols Portland LLC, USA, for a rotor vane used in an engine lubrication oil-pump system (Fig. 6).

The part is sized, face ground, deburred, and cleaned. The product application requires high accuracy of rotor radial dimensions, ID spline and vane-slot features to reduce internal pump leakage and achieve the required system mechanical efficiency.

Headquartered in Portland, Maine, Nichols Portland designs and manufactures PM components for use in fluid transfer devices and other automotive and industrial applications.

www.nicholsportland.com

Fig. 6 This rotor vane was manufactured by Nichols Portland and is used in an engine oil-pump system (Courtesy MPIF)

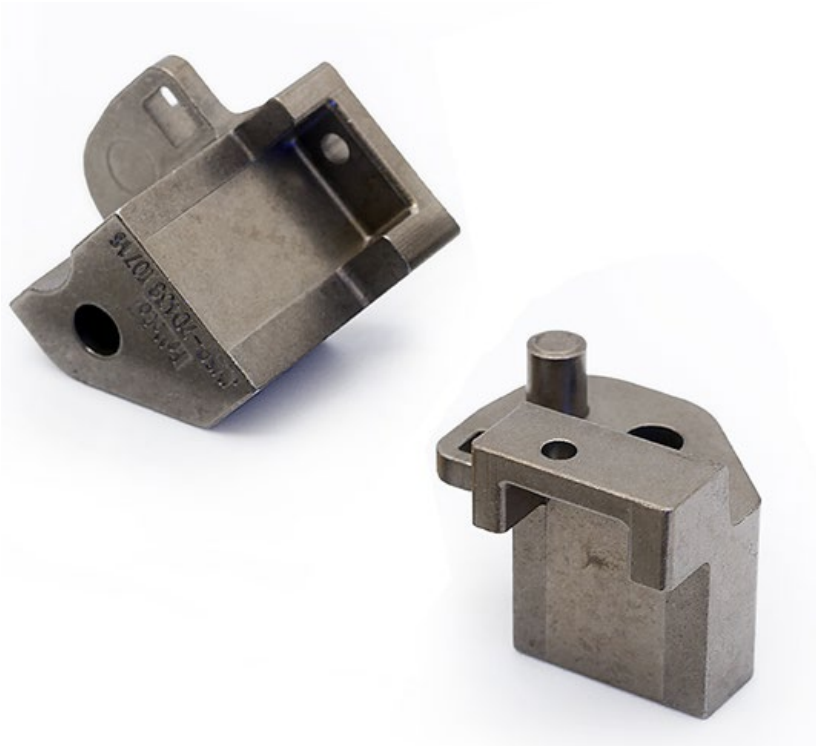


Fig. 7 This park range sensor control bracket, manufactured by GKN Powder Metallurgy, offers greater tolerance control, at a lower cost, compared to competing processes (Courtesy MPIF)

Fig. 8 The fan clutch assembly from FMS Corporation is used in large diesel-engine vehicles (Courtesy MPIF)

Automotive-Transmission: GKN Powder Metallurgy

In the Automotive-Transmission Category, an Award of Distinction was won by GKN Powder Metallurgy and Ford Motor Company for a transmission park-range-sensor control bracket (Fig. 7). The bracket acts as a stop to prevent over-travel of a transmission control rod in an automatic transmission park system.

The PM bracket provided greater tolerance control, at a lower cost, compared to competing processes. No secondary operations were required and, while mechanical properties were not a major concern in this component, the positional tolerance of the part once bolted in place was critical.

GKN Powder Metallurgy has 28 facilities in nine countries, and delivers more than 13,000,000 parts to its customers every day. GKN Powder Metallurgy employs 7,400 people, and is the largest manufacturer of PM components in the world.

www.gknpm.com

Automotive-Chassis: FMS Corporation

An Award of Distinction was won by FMS Corporation, USA, in the Automotive-Chassis Category for these fan clutch assembly components (Fig. 8). Made for its customer, Kit Masters Incorporated, the components are used in cooling systems for semi-tractors and other large diesel-engine vehicles.

The six PM parts include a bushing-tensioner retainer and an index coupler. All six parts are made from FC0208-50. The PM parts replaced machined components and offered a 60% cost saving.

Family owned and operated, the FMS Corporation, Powder Metal Division, based in Minneapolis, provides customised PM manufacturing services from parts design and alloy development through production and assembly.

www.fmscorporation.com

Fig. 9 FMS Corporation also manufactured this camshaft and water pump sprocket, which incorporates a one-piece shaft/sprocket design (Courtesy MPIF)

Hand Tools/Recreation: FMS Corporation

A second Award of Distinction was won by FMS Corporation in the Hand Tools/Recreation Category for Conventional PM components for camshaft and water-pump sprockets made for its customer Polaris Industries Inc (Fig. 9).

The parts are used in the Polaris Slingshot, three-wheel, side-by-side 'moto roadster'. The water-pump sprocket was especially challenging, as the customer desired a one-piece shaft/sprocket design. The PM components represent a 40% cost saving compared with machining.

www.fmscorporation.com

Hardware/Appliances: Webster-Hoff Corporation

In the Hardware/Appliances Category for Conventional PM components, an Award of Distinction was won by Webster-Hoff Corporation, USA, and its customer Humanscale, for a ratcheting lock (Fig. 10). The component is part of the locking mechanism in an adjustable office chair arm.

Unique fixturing is needed during sintering so that the part can meet the tolerances required for the post-sintering, drilling, and tapping operation.

Webster-Hoff, based in Glendale Heights, Illinois, processes a wide range of PM materials. The company has tooling, as well as numerous heat treatment and secondary equipment, in-house.

www.webster-hoff.com

Metal Powder Industries Federation

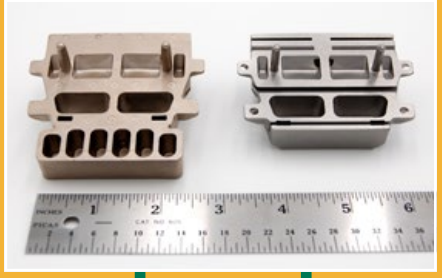
www.mpif.org

Fig. 10 This ratcheting lock, manufactured by Webster-Hoff, forms part of a locking mechanism in an adjustable office chair (Courtesy MPIF)

ABSTRACT SUBMISSION DEADLINE: OCTOBER 4, 2019

MIM 2020

International Conference on Injection Molding of Metals, Ceramics and Carbides
March 2–4, 2020 • Hotel Irvine • CA



Call for Presentations

MANUFACTURING INNOVATIONS:
- Part design
- Tooling
- Molding
- Debinding
- Sintering

MATERIALS ADVANCEMENTS:
- Metals & alloys
- Ceramics
- Hardmaterials

TARGETED AUDIENCE:
- Product designers
- Engineers
- End users
- Manufacturers
- Researchers
- Educators
- Students

Conference Sponsors:

MIMA
Metal Injection Molding Association

MPIF APMI INTERNATIONAL
Metal Powder Industries Federation
APMI International

Visit MIM2020.org to submit an abstract.

APMA 2019: India welcomes the fifth International Conference on Powder Metallurgy in Asia

In February 2019, the Powder Metallurgy Association of India (PMAI) hosted APMA 2019, the 5th International Conference on Powder Metallurgy in Asia, together with the 45th Annual Technical meeting of PMAI. Held in Pune, it was the first time the APMA conference had taken place in India. Professor Ramamohan Tallapragada, PM Consultant, Mumbai, India, provides an overview of the event, highlighting a number of key presentations.

The Indian city of Pune, the second largest city in Maharashtra and the ninth most populous city in the country, welcomed over 600 delegates from across Asia and the rest of the world to the 5th APMA International Conference on Powder Metallurgy in Feurary 2019. Organised by the Asian Powder Metallurgy Association (APMA) and the Powder Metallurgy Association of India (PMAI), the conference was held in conjunction with the 45th Annual Technical meeting of the PMAI and included over 170 technical papers presented in keynote, technical and poster sessions. Six special interest seminars focussed on conventional press and sinter PM, Powder Injection Moulding, Additive Manufacturing, hard metals and diamond tools, technical ceramics and composites, and material and alloy development for emerging applications.

A vibrant exhibition included some forty-two international exhibitors, with a number of networking and social events organised over the three days.

During the conference's opening ceremony, Narasimhan Gopinath, PMAI past president, welcomed delegates and thanked the event sponsors, exhibitors, and all involved with the organisation. The conference was then officially opened with the traditional 'lighting of the lamp' ceremony (Fig. 1).

Fig. 1 The conference was opened by the traditional lighting of the lamp ceremony (left to right: Prof P Ramakrishnan, Prof G S Upadhyaya and Prof Tallapragada R Rama Mohan; with Rajendra Sethia in the background)

Fig. 2 Chiu-Lung Chu, President of APMA, presented an overview of the Asian PM industry (Courtesy APMA)

Global trends in Powder Metallurgy

Growth in Asia's PM industry

In the Plenary session, Chiu-Lung Chu, President of APMA, gave an overview of the association's activities as well as the growth of the PM Industry in Asia (Fig. 2). APMA was formed during the 2008 PM World Congress in Washington D.C., USA, with the initial participation of three member countries: Korea, Japan and Taiwan. As of today, it has six member countries with nine member associations, two each from China (CPMA and CPMS), Japan (JPMA and JSPM) and Korea (KPMA and KPMI), along with India's PMAI, Taiwan's TPMA and Thailand's Thai PMA.

China is the largest PM part-producing member, and manufactured a reported 185,000 tons of PM parts in 2017 (Fig. 3). In the same year, Thailand produced about 17,000 tons, Indonesia 6,000 tons, Malaysia 4,000 tons and Singapore 2,000 tons. In 2017, Chu stated that all countries had growth in the year, except for Thailand and Malaysia, both reporting a small decline in sales.

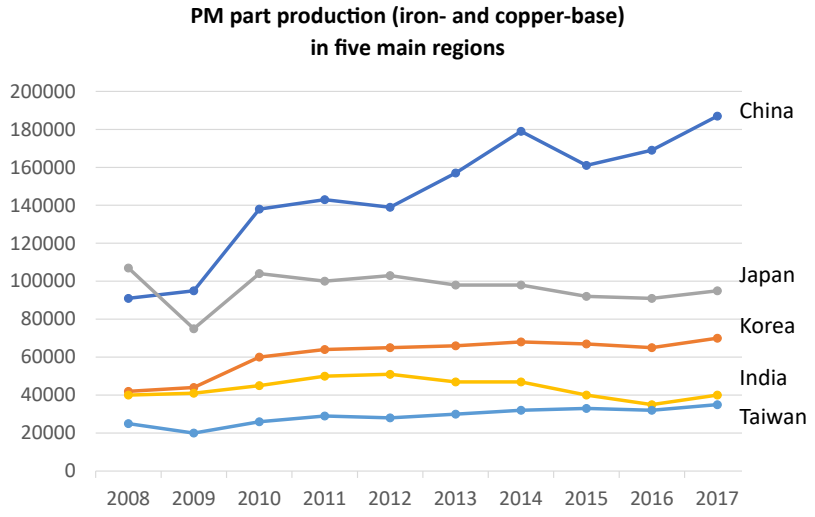


Fig. 3 PM part production in Asia's five main regions (Source APMA)

Turbulant times in Europe and North America

Following Chu's presentation, Dr Cesar Molins, Vice President, EPMA, and Director General of the AMES group, gave an overview of PM in Europe and America (Fig. 4). While the PM market in Asian countries is generally performing well, the western PM market is undergoing turbulent times, he reported. However, although the US market is generally down, it is somewhat lifted by the increasing production of SUVs with powerful engines; the consumption of PM parts in North American automobiles is increasing, typically in sedans at 27 kg, mid-size vehicles at 20 kg and large pickups at 34 kg. Double digit growth was said to be expected in 2019–20.

Europe's commitment to green technology and low/no-CO_2 emission vehicles was said to have been limiting the growth of PM, Molins added. However, growth is expected in the coming years with the development of new IC engines offering 20–30% lower emissions, and an increase in electric cars, where the transmission parts are still made from PM. Improvements in tooling and pressing equipment, typically for MIM, HIPing, aerospace and the biomedical industries, etc, were also said to be generating new markets, which sustain the growth of PM in Europe. The latter is aided by technologies such as lubricants, premixes, energy-efficient processes, improved testing techniques and emphasis on zero defects.

Additive Manufacturing seems to be making inroads, but the technology is likely to take some time to be able to cater to the exacting standards demanded by automotive structural parts, added Molins. Electric cars – both hybrid and fully electric – are being developed and used in China, Europe and in the USA. However, the low availability of charging stations, high-voltage batteries and problems associated with their recycling are limiting factors at this time. Fuel-cell cars were said to be slowly gaining ground.

Opportunities for Powder Metallurgy in a changing market

In his keynote presentation, Mark Braithwaite, President of Höganäs AB in the Asia-Pacific region, spoke about trends that will affect the Powder Metallurgy sector over the next decade, and how the industry needs to pull together to meet these challenges (Fig. 5).

Industrial growth in general was said to have slowed to 2–3%, partly attributed to a decrease in mobility, particularly of the middle class. However, an increase in this segment over the next ten years is expected to improve the growth rate. There are also political and technological uncertainties associated with new vehicles, such as those associated with electric cars and fuel cells, he stated. Users of electric cars are generally happy with their experience, and thus hybrid and electrical drives are likely to dominate, while IC engines are likely to become smaller, Braithwaite said.

India, Indonesia, China and other Asian countries are expected to continue to show natural growth, he added. IC engines will continue to have a market for at least ten years, but transmission parts will become more important. Braithwaite believes that the future will see more hybrid engines and automation in general, which will give plenty of opportunity for the development of new components made using Powder Metallurgy.

Reporting on the activities at Höganäs, he stated that the company's PoP centres are increasingly assisting customers in the development of new components in conventional PM, electromagnetic and soft magnetic applications, and more. Digital Metal AB, the company's Additive Manufacturing firm, last year produced around 100,000 AM parts, he added.

In closing, Braithwaite urged all PM industries to come together to develop new components and technologies, so that PM technology as a whole is able to meet the many new challenges it faces.

Fig. 4 Dr Cesar Molins presented an overview of PM in Europe and America (Courtesy APMA)

Fig. 5 Mark Braithwaite, President APAC Höganäs, spoke on PM trends in the next decade (Courtesy APMA)

PM parts for new propulsion systems

During the Symposium on Press and Sinter Technology, Rohith Shivanath, of Stackpole International Inc., Ontario, Canada, gave a keynote address on the scope of PM Technologies in the development of new propulsion systems (Fig. 6).

As the trend towards electrification and new propulsion systems for vehicles rapidly increases, major challenges are posed to PM component manufacturers and their traditional markets, he said. If PM is to meet this challenge and maintain a market share in electrified vehicles, the range of mechanical properties achievable by PM, in particular dynamic strength, must be increased to match the durability of wrought low-alloy steels.

Shivanath discussed the properties required for transmissions and the tools available to improve PM part properties so that highly-loaded gears may be designed and produced in a cost-effective manner. Some of

Fig. 8 Rohith Shivanath, of Stackpole, discussed PM Parts for new propulsion systems (Courtesy APMA)

Fellow of PMAI presented to N Gopinath

Fig. 9 N Gopinath, Managing Director of Fluidtherm Technology, was conferred with the title Fellow of PMAI (FPMAI) for his service to the Indian PM industry

During APMA 2019, N Gopinath, Managing Director of Fluidtherm Technology and past-president of the PMAI, was conferred with the title Fellow of PMAI (FPMAI) for his service to the Indian PM industry.

Fellowship of the PMAI is conferred upon individuals who have demonstrated significant contributions to the science and practice of Powder Metallurgy, the growth of the Indian PM industry and the growth of PMAI.

"Gopinath has met these criteria in abundance by developing unique processes and world-class furnaces for Powder Metallurgy, making these available in India and around the world, and for his efforts that made PMAI an internationally respected body," stated Aniket Gore, President of PMAI.

the tools discussed were optimised designs for lower stresses, highly-compressible cost-effective lean alloy powders, high-temperature sintering facilities, improved densification methods and special/vacuum heat treatment.

Mechanical property data showed that a wide range of highly-loaded gears can be successfully produced by PM, offering gear designers new solutions for electrified vehicles. The noise dampening attributes of PM were discussed as a further advantage for gear designers for electrified vehicles.

PM as an enabler for next generation xEV powertrains

Manjeet Dhiman, also from Stackpole International Inc., continued the theme with his presentation on the use of Powder Metallurgy for the next generation xEV powertrains.

OEMs and transmission manufacturers are challenged with the integration of e-motors and batteries into already highly-packed powertrain architectures, he stated, which requires the power density of highly-integrated and compact components. Added to this, e-motor speeds, which are up to five times higher than conventional ICE speeds, demand stiff, lightweight and high-quality balanced solutions, particularly with regard to pure electric driving when there is no ICE masking the NVH of the drivetrain.

PM design features can contribute solutions to these challenges, Dhiman said. Near-net shape off-tool design can drive functional integration and compactness to achieve lightweight improvements. With new joining technologies for PM and conventional steel components, power density can be further improved. NVH can also be reduced, he said, using the dampening effect of PM-specific part porosity, and higher balancing quality of high-speed rotating elements can be achieved by even weight distribution.

The APMA 2019 exhibition was a showcase for some forty-two international exhibitors

Methods of achieving higher density in PM parts by cold compaction

On day two of the Press and Sinter symposium, Kalathur Narasimhan, of P2P Technologies (Philadelphia, USA), illustrated the use of cold compaction to achieve high density in PM parts.

The need for higher mechanical strength from current PM components requires new approaches to achieve higher densities, he stated. Hoeganaes Corporation, USA, introduced the concept of warm compaction in 1993, which required the development of new lubricants, and is quite inconvenient for part makers due to the need to heat the die, tools or powder.

The control of particle size distribution in atomised powders can be used to achieve high-density, less expensive PM parts with balanced mechanical properties. Initial work on FN-0205 mixes, using + 325 mesh (44 μm) base powder, was reported at the 2018 MPIF conference. Further investigations of + 325 compaction revealed that stripping force after compaction is significantly less with + 325 than heated die technology.

Cold ambient temperature compaction densities of 7.38 g/cm^3, with a stripping pressure of 18 MPa, were observed, compared with warm die compaction of similar mix density of 7.40g/cm^3 with a stripping pressure of 27 MPa. This presentation reviewed the higher density processes and reported the results on FLN2-4405 mixes.

New materials for emerging applications

A critical assessment of the new paradigms, faced in the development of novel materials and alloys developed through sintering techniques, was presented by Anish Upadhyaya of IIT Kanpur.

Among various materials processing technologies, Powder Metallurgy has established itself as a manufacturing process capable of delivering a wide range of new materials, microstructure and properties, he stated. One attraction of PM is the ability to fabricate high quality, complex parts to close tolerances with low relative energy consumption, high material utilisation and low capital cost. This has created several unique niche applications for PM in high-performance applications.

Various parameters that influence the densification and microstructural evolution during sintering were discussed. The phenomenological models relating various microstructural attributes to densification were discussed, both for solid state and liquid phase sintering for a range of systems, using both conventional as well as microwave sintering. The ongoing efforts to correlate the microstructural evolution during sintering were discussed with reference to the effect of thermo-mechanical processing on the sintered microstructure.

Fig. 10 Hyong Seop Kim of Postech Korea discussed the processing of high entropy alloys (HEAs) by PM (Courtesy APMA)

High entropy alloys

During the same session, Hyong Seop Kim of Postech Korea discussed the processing of high entropy alloys (HEAs) by PM (Fig 10). High entropy alloys are designed with a large number of alloying elements, with the content of each constituent element in the range of 5–35 at%. These are considered as advanced materials for next-generation structural materials for various applications, due to unique characteristics such as sluggish diffusion and lattice distortion, excellent cryogenic properties, high-temperature resistance and corrosion resistance as well as high strength and elongation. HEAs manufactured by PM were presented in terms of microstructure and mechanical behaviour, and compared with ingot metallurgy processed HEAs.

Bharat B. Panigrahi of IIT Hyderabad presented a comparative study of mechanical properties of AlCoCrFeNi high entropy alloy, processed through pressureless sintering and hot-pressing routes. For the reported work, AlCoCrFeNi was selected, because of its better combination of strength and high ductility. Nearly full density could be achieved by sintering at about 1275°C. In another set of experiments, mechanically alloyed powders were hot pressed at a temperature of 1100°C, at a pressure of about 30 MPa.

A comparative study was made on phase evolution behaviour, microstructure evolution and mechanical properties. Results suggested that properties of pressureless sintered components were comparable with hot pressed samples.

Shailesh Gore of COEP used an arc melting route to develop eutectic HEA $CoCrFeNiM_x$ (M: Al, Cu and x=0, 0.1, 0.3, 0.5) alloys prepared by using combinations of mechanical

mixing, compaction and arc melting processes. SEM-EDS and XRD analyses were carried out to determine the various phases that were formed and the respective phase content was estimated using the rule for degree of alloying. The mechanical behaviour (hardness) of HEAs at room temperature and at elevated temperatures were reported.

Diamond tools and the reduction of cobalt

A keynote presentation from Janusz S Konstanty, of AGH University of Science and Technology, Poland, reported on current trends and advances in the fabrication and application of diamond tools.

Sharp rises in the price of cobalt, stated Konstanty, initiated an intensive search for cheaper matrix materials. Fortunately, rapid improvements in the cubic type, multi-anvil high pressure equipment and its large-scale implementation for diamond synthesis had resulted in tremendous price cuts on the diamond supply side.

As most diamond grits were used for sawing natural stone and concrete, new production techniques that emerged in the stone and construction industries in the 1990s brought pressure on tool-makers to develop new manufacturing routes and refine the existing tool designs in order to do the job faster, more accurately and at less cost. Thus, the main efforts were directed towards substituting fine cobalt powders with iron-base and copper-base alloys, overcoming unsatisfactory diamond grit retention and achieving its better distribution in the sintered matrix.

Following Konstanty's presentation, Iñigo Iturriza of the University of Navarra, Spain, discussed topics related to bond development, diamond stability and wear behaviour in diamond impregnated tools for stone cutting. Hundreds of millions of diamond-impregnated components (DIC) are produced every year by PM for stone processing and civil engineering applications. The R&D activity in DIC, from a PM point of view, is mainly focussed on the substitution of cobalt and the introduction of free sintering to replace hot pressing and HIP, stated Iturriza.

Fig. 11 Janusz S Konstanty, AGH University of Science and Technology, Poland, gave a Keynote address on current trends and advances in the fabrication and application of diamond tools (Courtesy APMA)

In addition, productivity has also been enhanced by the granulation of the powders, the introduction of volumetric filling of dies during the cold pressing step and the automation of the PM processing route. Even more, in recent years, in order to not only reduce Co but also the price of the bond, cheap premix powders, ball-mill powders, water atomised powders have been introduced together with prealloyed powders.

Continuing the theme of reducing cobalt, P. Chandra Sekar of Umicore India Pvt Ltd, Mumbai, discussed the optimisation of microstructures so as to remove cobalt in diamond impregnated tools. The metallic matrix plays a key role in the performance of diamond-impregnated tools (DIT), with wear mechanisms as the main phenomena contributing to the good behaviour of DIT, stated Sekar. However, it is a very complicated task to quantify the reaction of a new alloy without many field tests. Abrasion tests, commonly used to define matrix wear resistance (erosion, two-body and three-body abrasive wear tests), seemed to be insufficient to adequately imitate the conditions encountered in industrial cutting operations.

To better understand cutting mechanisms, a new wear test was developed, based on a core-drill machine, which evaluates the matrix wear as closely as possible to real stone machining conditions. The new protocol consists of a non-destructive observation of the worn surface around an active diamond. The clearance and protrusion were measured after cutting a quantity of concrete to be able to obtain the wear rates of each zone.

An equilibrium should appear between the clearance and protrusion wear rates to guarantee a good performance. Some grades of cobalt were compared with a new iron-base matrix. It was observed that a good correlation exists between cutting speed of tools and the ratio of the two wear rates.

Author

Prof Ramamohan Tallapragada
PM Consultant, Mumbai, India.
ramamohant@gmail.com

Contact

Powder Metallurgy Association India
www.pmai.in

Asian Powder Metallurgy Association
www.apma.asia

Developing the Powder Metallurgy Future

european powder
metallurgy association

CELEBRATING 30 YEARS EPMA european powder metallurgy association

International Congress & Exhibition

13 - 16 October 2019

Maastricht Exhibition & Congress Centre (MECC),
Maastricht, The Netherlands

Technical Programme Available Now

EURO PM2019 CONGRESS & EXHIBITION

www.europm2019.com

Euro PM2019 Mobile App Available now at www.europm2019.com/app

industry events

2019

EMO Hannover 2019
September 16-21, Hannover, Germany
www.emo-hannover.de

International Conference on Gears 2019
September 18-20, Munich, Germany
www.vdi-wissensforum.de

ceramitec conference
September 19-20, Munich, Germany
www.ceramitec.com/conference

PMTi 2019
September 24-27, Salt Lake City, USA
www.pmti2019.org

Euro PM2019 Congress & Exhibition
October 13-16, Maastricht, Netherlands
www.europm2019.com

International VDI Conference - Automotive Drives
November 6-7, Amsterdam, Netherlands
www.vdi-wissensforum.de

formnext 2019
November 19-22, Frankfurt, Germany
www.formnext.com

Hagen Symposium 2019
November 28-29, Hagen, Germany
www.pulvermetallurgie.com

EPMA Press & Sinter Showcase
December 3-4, Hary, France
www.epma.com

2020

MIM2020
March 2-4, Irvine, United States
www.mim2020.org

PM China 2020
March 24-26, Shanghai, China
www.pmexchina.com

Rapid + TCT 2020
April 20-23, Anaheim, United States
www.rapid3devent.com

WorldPM2020
June 27-July 1, Montréal, Canada
www.worldpm2020.org

formnext + PM South China
September 9-11, Shenzhen Shi, China
formnext-pm.hk.messefrankfurt.com

Pick up your free copy at PM related events worldwide

Powder Metallurgy Review magazine is exhibiting at and/or being distributed at events highlighted with the *Powder Metallurgy Review* cover image.

Event listings & media partners

If you would like to see your Powder Metallurgy related event listed in this magazine and on our websites, or wish to discuss a media partnership for your event please contact Paul Whittaker: paul@inovar-communications.com

Advertisers' index

No.1 in PM

DORST TECHNOLOGIES

TPA 250 HP Compact

- 2.500 kN multi-level ✓
- Floor level installation ✓
- No pit ✓
- Quick tool change ✓
- High efficiency ✓
- Cost-effectiveness ✓

MADE IN GERMANY

www.dorst.de