*Powder metallurgy (PM) companies are staying the course investing in new technology, materials, processes, and environmentally-friendly options. Powder makers are focusing on improved lubricants for PM sintering, soft magnetic composites for electric vehicles, and new alloys for 3D printing. Binder jetting of aluminum appears to be breaking out.*

# TECHNOLOGY FORECAST—2022

**By Peter K. Johnson**

## MPIF TECHNICAL BOARD

The Metal Powder Industries Federation (MPIF) Technical Board, chaired by Blaine Stebick of Phoenix Sintered Metals LLC, Brockway, Pennsylvania, will sponsor a Special Interest Program, Materials Properties and Processes, at the **PowderMet2022** conference in Portland, focusing on new technology advances. The Tech Board has also completed updating the PM Industry Road Map for release at the conference, identifying new technical barriers, challenges and priorities impacting PM's future.

Stebick sees the electrification of vehicles as a "front-and-center" issue for the PM industry as it impacts the design and production of internal combustion engine (IC engine) vehicles. Currently electric vehicles account for about 3–5% of the North American fleet. The Tech Board continues to monitor potential PM applications.

Additive Manufacturing (AM) is another Tech Board focus relating to Metal Injection Molding (MIM) and press & sinter PM, as a complementary process rather than a competitor.

## METAL POWDER TRENDS

Hoeganaes Corporation (hoeganaes.com), Cinnaminson, New Jersey, continues focusing on clean-burning, environmentally-friendly lubricant options, says Kylan McQuaig, senior manager business development.

Current advanced lubricants offer higher densities at lower additions without the need to heat tooling in a tight temperature range. This results in opening the compaction operating window, McQuaig explains.

While these lubricants can also provide easier de-lubrication during sintering, they also offer other benefits such as lessening environment impact, cleaner parts, and improved magnetic performance in soft-magnetic applications. Figure1 shows the ejection performance of several common lubricants in an FC-0208 premix, compared with two advanced metallic stearate-free lubricants.

Hoeganaes technologists see the electrification of the automotive market impacting PM trends in the next decade. For example, demands for soft-magnetic composite (SMC) parts will grow with increasing applications in AC electric motors. Standardizing SMC grades is important over the next few years as MPIF member companies work together to demonstrate the benefits over traditional lamination steels.

Developing new, higher temperature SMC coatings will be a key objective for powder makers to increase possible curing temperatures, leading to higher permeability, lower core loss, and increased part strength. Figure 2 illustrates the increase in core loss typically occurring at curing temperatures ~500 °C as SMC coatings begin breaking down. High-temperature coatings potentially

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allow higher curing temperatures for annealing iron, and superior magnetic properties in cured parts, compared with SMC materials currently available.

Roland Warzel III, director, technical service of North American Höganäs (hoganas.com), Hollsopple, Pennsylvania, reports his company will continue seeking machining solutions for PM parts manufacturing. Green machining programs have increased with its new Intralube GS system that produces PM premixes that provide high green strength in compacted parts, he reports.

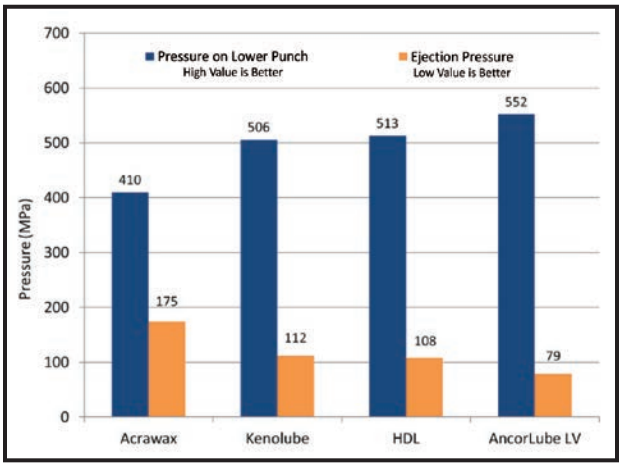


***Figure 1.*** *Performance of different PM lubricants at 0.6 wt.% addition in an FC-0208 premix*

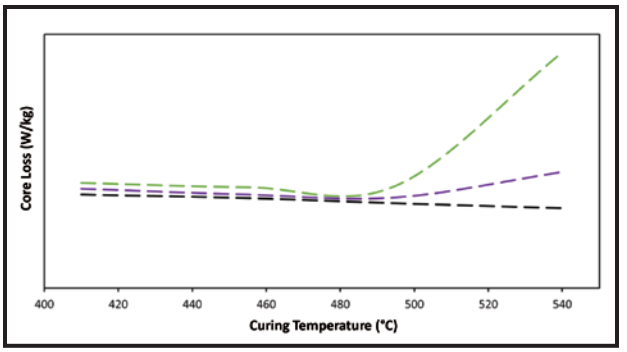


***Figure 2.*** *Effectiveness of three experimental coating materials on cured AC magnetic properties at a frequency of 1 kHz*

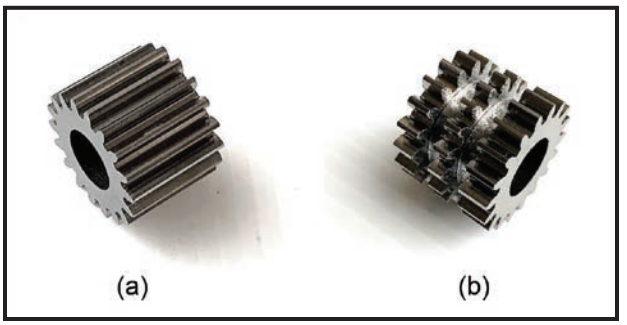


***Figure 3.*** *(a) Green gear blank (FL-5305); (b) Triple sprocket via green machining with Intralube GS-based mix (FL-5305)*

The company's Machining Customer Development Center (CDC) has developed machining conditions that allow interrupted green grooving in manufacturing double/triple sprockets (Figure 3) via green machining with an Intralube GS-based material. High green strength is critical for the strength required during machining, and important for efficient crack-free processing.

Rio Tinto Metal Powders (RTMP) (qmp-powders.com) Sorel-Tracy, Quebec, Canada, reports steady interest in soft-magnetic composite (SMC) applications for electric vehicles and non-automotive products, says Vincent Paris, principal advisor–metallics. The company has established technical partnerships with academia and end-users to assist customers developing magnetic applications. RTMP also supports the standardization of magnetic materials by the Metal Powder Industries Federation.

While AM is becoming more and more viewed as a complementary production technology to traditional PM, the high cost of raw materials is a limiting factor, RTMP observes. It is solving this problem by offering water-atomized powders suitable for different AM processes, including laser-beam powder-bed-fusion (PBF-LB) and cold spray AM.

The company has researched optimal processing parameters to enhance the properties of printed parts using ATOMET 1025, a readily printable low-carbon steel. In addition, it has been working on ATOMET 4340, a low-alloy water-atomized powder, an equivalent to AISI 4340. The material can be used in several well-accepted AM processes and is particularly suitable for binder jetting (BJT).

Kobe's Steel Powder Unit (kobelco.co.jp), Toyko, Japan, continues the Segless KS series with a new enhancer KS-600X being tested by customers, reports Tetsuya Sawayama, general manager. Its new KS-300A lubricant is in commercial production. In addition, Kobe's Magmel surface-insulated iron powder is finding applications in soft-magnetic composites. Several customers are evaluating SMCs in axial gap motors.

Kymera International (kymerainternational.com), Research Triangle Park, North Carolina, offers standardized aluminum alloy grades for laser-beam powder-bed-fusion (PBF-LB), reports Joe Croteau, technology manager, special materials. The grades include AlSi10Mg, AlSi70.6Mg and AlSi9Cu3. Kymera has additionally introduced Custalloy, a new alloy for PBF-LB processing.

Printed alloys can be heat treated to achieve a high ductility above 20%, or high yield strength exceeding 480 MPa (70,000 psi).

Kymera is building a comprehensive data base to support PBF-LB aluminum customers, and reports growing interest in aluminum alloys for binder jetting.

The company continues developing processes and applications for sintering aluminum alloys for binder jetting; 2000-, 4000-, 6000-, and 7000-series.

Novamet/Ultra Fine Specialty Products (novametcorp.com), Lebanon, Tennessee, is expanding production of highly spherical gas-atomized alloy powders for AM and MIM applications, says John L. Johnson, vice president of operations and technology.

The company has installed capacity for pilot quantities of gas-atomized powders for custom alloys aimed at powder-bed-fusion processes and binder-jet printing. The equipment will provide narrow particle-size distributions, improve sphericity, and reduce satellites. Upon successful evaluation, quantities can be scaled to high volumes on existing equipment.

Valimet Inc., (valimet.com), Stockton, California, believes applications of aluminum and aluminum-alloy powders are moving beyond aerospace applications into the additive manufacturing market, reports Christopher T. Adam, president. Traditional AM aluminum alloys (AlSi10Mg, F357, A20X) are specified for many critical parts.

Standard wrought alloys (2000-, 6000- and 7000-series) are being used in AM via novel treatments and processes. Binder jetting aluminum is becoming a reality, Adam says. For example, inventive processing methods are breaking down oxide barriers that should support mass production of aluminum AM products.

Cold spraying aluminum alloys is gaining more applications in the field for military or industrial uses. Portable spray systems can form parts and make on-site repairs.

Additional aluminum powder advances include high-strength/high-temperature alloys, replacing titanium for applications above 300 °C. These alloys have high cooling rates generated during laser-beam powder-bed-fusion to form unique grain structures. Innovative alloys containing cerium, scandium, zirconium ,and other additions are expanding aluminum's traditional operating window.

Aluminum based metal-matrix-composites play a critical role in aerospace and high-performance parts. Pure aluminum powder and alloying elements mixed with ceramic reinforcement are hot pressed, extruded and machined, resulting in parts with unmatched stiffness and wear, Adam says.

### *Equipment Trends*

Abbott Furnace (abbottfurnace.com), St. Marys, Pennsylvania, reports success with the Vulcan Process in 3D printing of aluminum via binder jetting, reports Stephen L. Feldbauer, director, research and development. "We helped a customer successfully use the Vulcan Delube System for de-binding and high-density sintering of aluminum 3D printed automotive parts," he says.


***Figure 4.*** *Vulcan System*

The Vulcan process (Figure 4) uses convective heating to control temperature and heating precisely in an optimal temperature range for binder removal and sintering. It opens many new applications for aluminum in additive manufacturing. The system is also used for conventional PM parts de-lubing and sintering, improving mechanical properties by 18–20%.

Centorr Vacuum Industries (centorr.com), Nashua, New Hampshire, realized a sizable jump in business in 2021, reports Scott K. Robinson, product manager. Startup MIM and 3D/AM operations, and established customers launching new product lines requiring additional furnace capacity ordered the new equipment. Centorr also reports an upsurge in high-temperature furnace processing for the carbon/graphite and advanced ceramics markets.

Heath Jenkins, president, Press & Automation, Gasbarre Products, Inc. (gasbarrre.com), DuBois, Pennsylvania, reveals increased interest in multi-cavity tooling (Figure 5), which allows PM parts makers to double or triple production without adding new equipment. "With sufficient press and ejection force, and appropriate tool-guidance precision and die filling, you can quickly increase production," he says.

Gasbarre has improved hydraulic press technology with more servo-hydraulic actuators, that integrate the hydraulic cylinder, pump, power electronics and manifold into one compact unit, Figure 6. The decentralized system combines the power density of hydraulics with the dynamics, accuracy, and flexibility of electric servos in a small oil system. This advantage eliminates the need for a large centralized hydraulic power unit and oil reservoir.

### *PM & Additive Manufacturing Product Trends*

According to Chaman Lall, vice president technology and applications development, MPP (mppinnovation.

com), Noblesville, Indiana, is expanding the marketplace for PM aluminum parts in non-automotive space. R&D programs have focused on components with strengths comparable to sintered PM steels.

MPP offers the traditional AC-2014 alloy featuring an ultimate tensile strength (UTS) of about 200 MPa (29,000 psi), as well as an Al-2.5%Cu alloy with a UTS of about 300 MPa (43,000 psi) and a new Al-Zn alloy with a UTS of up to 400 MPa (58,000 psi). These strength values are based on lab testing of non-heat-treated tensile bars.

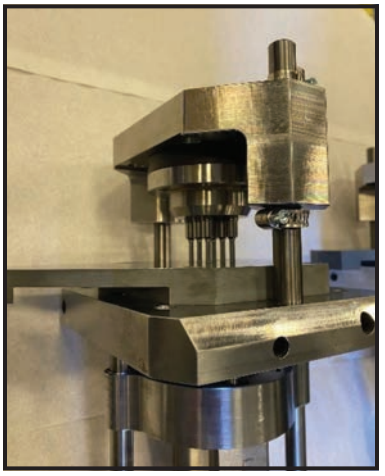

***Figure 5.*** *Multi-cavity tooling*

***Figure 6.*** *Bosch Rexroth servo hydraulic actuator*

***Figure 7.*** *Full scale RS 25 rocket engine nozzle printed in multi-nozzle DMD system*

MPP is strategically seeking non-firearm MIM technology applications, Lall stresses. MPP is also conducting significant development work in new applications using high performance soft-magnetic composites, and non-leaded PM materials offering the bearing performance of leaded brass and bronze.

Silvio Bartoletti, director of Metalpo Industria e (metalpo.com.br), San Paulo, Brazil, sees new 3D printers featuring high-speed production, offering lower production costs will provide multi-material parts. In addition, electric vehicles with new electric motors will expand demand for soft-magnetic composites.

Desktop Metal (desktopmetal.com), Burlington, Massachusetts, has acquired 3D printing companies ExOne and Aidro in 2021, reports Animesh Bose, vice president special projects. ExOne extends Desktop's product platforms. Aidro, a pioneer in volume production of next-generation hydraulic and fluid power systems via AM, will open the door to 3D printing high-performance hydraulic valves and manifolds for the energy and aerospace markets.

Desktop has recently opened an in-house manufacturing unit that more than triples final assembly space for single pass jetting process. The company also launched Desktop Health for 3D printed dental and bio-fabrication applications. It has expanded to include a turnkey 3D printing unit for chrome-cobalt parts.

Bhaskar Dutta, president and COO of DM3D Technology, LLC (dm3dtech.com) Auburn Hills, Michigan, reveals his company has produced the largest 3D printed shape, a prototype nozzle jacket for NASA's RS 25 rocket engine in its multi-nozzle DMD system, Figure 7. The part has a base diameter of 242 cm (95 inch), is 277 cm (109 inch) high, and weighs 1,845 kg (4,100 lb). Dutta says DM3D customers are requesting 3D printing of non-ferrous metals such as aluminum and copper alloys.

TAT Technologies LLC, St. Marys, Pennsylvania, announces an alternative double press/double sinter method to fabricate high-density low-alloy steel parts, according to Harb S. Nayer, FAPMI, president. The process uses water-atomized prealloyed Fe-Ni-Mo powder that offers a high degree of homogeneity at 7.3 g/cm$^3$ without high-temperature sintering.

TAT Technologies with several industrial and university partners, is working on further steps using the DPDS route: full density via hot isostatic pressing with no interconnecting porosity; high quench rate HT, giving surface compressive stresses for higher mechanical properties and corrosion resistance; and reporting microstructures, mechanical properties, and fatigue strength. ijpm